TESIS DOCTORAL

Three Essays on Environmental Innovation and Corporate Social Responsibility

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INTRODUCCIÓN

Dada la creciente presión sobre las organizaciones para cumplir con metas sociales más amplias (Matten & Crane, 2005), las firmas responden incluyendo la responsabilidad social corporativa (RSC) como una forma de reducir las tensiones entre las *necesidades humanitarias* de las firmas hacia grupos más amplios de stakeholders y *compromisos económicos* con propietarios/stakeholders (Margolis & Walsh 2003; Carroll, 1991). La RSC no sólo provee beneficios a la firma (Porter & Kramer, 2006; Graafland et al., 2003), sino que también es claro que "una corporación puede tener un buen desempeño haciendo el bien" (Kotler & Lee, 2005).

Actualmente cerca del setenta por cien de las firmas de capital abierto en los 34 países más grandes adoptan RSC (KPMG, 2011). Sin embargo, un número de firmas emplean RSC del tipo 'lavado verde' o 'greenwashing'. Aunque también existen firmas que son más 'sinceras' acerca de su implicación en RSC. En esta tesis tomamos prestado de la teoría institucional, donde la RSC está considerada como una parte de la nueva legitimidad (Matten & Moon, 2008; Wood, 1991), para mejorar nuestra comprensión sobre el tema. Nuestro primer estudio trata específicamente la influencia de presiones institucionales en la actitud individual del manager acerca de RSC y en los diferentes tipos de RSC que la firma toma.

La evidencia empírica sobre RSC se ha centrado hasta ahora, casi exclusivamente, en la respuesta de las firmas a presiones externas y raramente considera las presiones internas (Mayo et al., 2013). El marco teórico híbrido que ofrecemos en el primer estudio ayuda a contribuir a la literatura en el sentido de que ni factores externos ni factores internos por sí solos tienen la capacidad de proveer una explicación sobre conductas organizacionales.

La literatura ha identificado, por ejemplo, estrategias de prevención de polución e innovación ambiental como RSC con fondo (Klassen and Whybark, 1999; Russo and Fouts, 1997; Hart, 1995). Esto da pie al segundo y al tercer artículo de esta tesis doctoral.

Las empresas están siendo presionadas para lograr *metas más verdes* junto con sus *metas económicas* (Elkington, 1994; Johnstone et al., 2008). Dado que uno de los mecanismos para que las firmas lidien con el cambio ambiental es a través de innovaciones (Schoonhoven et al., 1990), la innovación ambiental se presenta como una opción apropiada para tratar con esta presión creciente y el contexto cambiante (De

Marchi, 2012; Johnstone et al., 2008). En el segundo capítulo, examinamos la estrategia de búsqueda de innovación ambiental de las firmas. En el tercer capítulo, examinamos el impacto de la innovación ambiental en el empleo.

En este momento, el estudio sobre innovación ambiental es aún escaso (Chang, 2011; Horbach, 2008; Toshi et al., 2007). Con el segundo estudio, ayudamos a arrojar luz sobre la estrategia de búsqueda de innovación ambiental de las firmas, específicamente sobre dónde buscan conocimiento y la importancia de cada fuente de conocimiento para firmas de diferentes tamaños. Dado que analizamos varias fuentes de conocimiento juntas, podemos evaluar también el grado de apertura de la estrategia de búsqueda de las firmas. En este artículo, lo llamamos 'breadth' o 'amplitud'.

Uno de los tópicos más comúnmente tratados durante debates políticos tiene que ver con la pregunta de cómo las transformaciones de las firmas hacia ser verdes afecta el desempeño económico y el empleo (Rennings et al., 2004). Aún así, los efectos de la innovación ambiental sobre el empleo no son particularmente bien conocidos y las diferentes visiones sobre el tema, así como los posibles impactos, estimulan el debate, que se mantiene vigente. Con el tercer artículo, intentamos reducir la brecha proveyendo más evidencia empírica al nivel de la firma. Analizamos los impactos, tanto de manera agregada, como de manera individual para cada tipo de innovación ambiental. Descomponemos la innovación ambiental entre voluntaria e impulsada por el cumplimiento. Nuestro estudio también tiene importantes implicaciones, particularmente en el diseño de micro-políticas que ayudarán a mejorar el crecimiento del empleo.

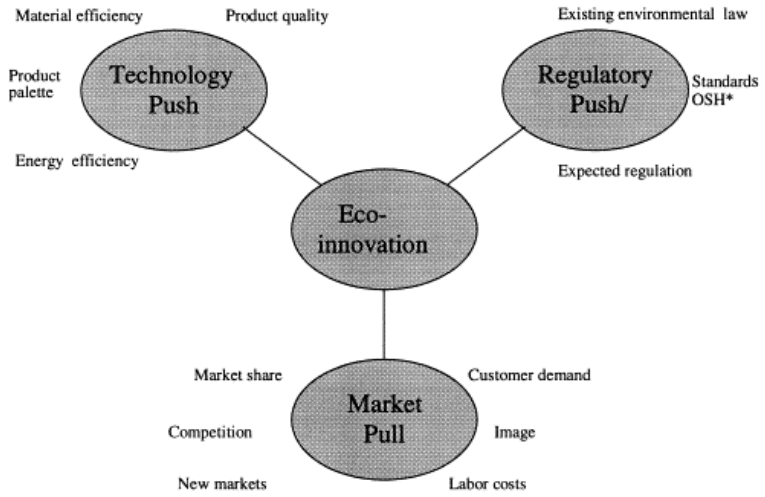
Definición: Responsabilidad social corporativa (RSC)

En esta tesis doctoral, el término RSC recoge "expectativas económicas, legales, éticas y discrecionales que la sociedad tiene sobre las organizaciones" (Carroll, 1979: 500). En esencia, implica conducir las empresas de una manera que sea económicamente rentable, que cumpla con la legislación vigente y que brinde apoyo social y ético.

Definición: Innovación ambiental

La innovación ambiental es similar a la innovación en general (van Leeuwen & Mohnen, 2013). Sin embargo, a diferencia de innovaciones convencionales, factores del empuje de la tecnología (technology-push) y la demanda del mercado (market-pull) por sí mismos no proveen suficientes incentivos para que las firmas se involucren en innovación ambiental (Rennings, 2000). La innovación ambiental produce los mismos efectos secundarios (spillovers) de la innovación tradicional, pero además genera menos costos ambientales. Mientras que la sociedad como un todo se beneficia de la innovación ambiental, es la firma quien carga con los costos de ésta. A pesar del hecho de que una cierta innovación verde puede ser comercializada exitosamente, la habilidad de las firmas de apropiarse de los beneficios de tal innovación puede ser difícil si los beneficios ambientales tienen un carácter de bien público o el conocimiento correspondiente es fácilmente asequible. Adicionalmente, mientras los mercados no castiguen impactos ambientales perjudiciales, se distorsiona la competencia entre innovadores ambientales e innovadores no ambientales. Las fuerzas del mercado por sí mismas no proveen suficientes incentivos de innovación y la disposición de los consumidores a pagar por características ambientales sería muy baja. Esto es lo que Rennings (2000) llama 'problema de doble externalidad'. Consecuentemente, este problema lleva a una importancia creciente del marco regulatorio, puesto que tales externalidades resultan en inversión sub-óptima en innovaciones ambientales. En este contexto, la política ambiental se convierte en una fuerza importante para dar empuje a las innovaciones verdes. Véase la Figura 1.

FIGURA 1
Un modelo de determinantes de la innovación ambiental



Fuente: Rennings, 2000.

Los términos eco-innovación, innovación ambiental e innovación verde han sido y aún son utilizados como sinónimos (Tietze et al., 2011). En esta tesis doctoral adoptamos la siguiente definición:

> "Las innovaciones ambientales consisten en procesos, técnicas, prácticas, sistemas y productos, nuevos o modificados, para eludir o reducir el daño ambiental. Las innovaciones ambientales pueden desarrollarse con o sin el objetivo explícito de reducir el daño ambiental. También pueden ser motivadas por las metas usuales de la empresa, tales como reducción de costos o mejorar la calidad del producto. Muchas innovaciones ambientales combinan un beneficio ambiental con un beneficio para el establecimiento o usuario" (Hemmelskamp, 1997; Rennings, 2000; Rennings et al., 2004: 376).

Conclusión:

A través de los tres artículos sobre RSC e innovación ambiental, esperamos proveer nuevas percepciones sobre cómo las firmas pueden tratar con RSC y la innovación ambiental en esta economía moderna donde hay una demanda elevada para firmas que se comportan de una manera no sólo responsable socialmente, sino también amigable con el medio ambiente, acercándose a la sostenibilidad.

INTRODUCTION

As the world is increasingly exerting pressures on organizations to fulfill broader social goals (Matten & Crane, 2005), firms respond by including CSR as a way to ease tension between firms' *humanitarian needs* towards broader stakeholder groups and *economic commitments* towards owners/shareholders (Margolis & Walsh 2003; Carroll, 1991). Not only that CSR provides benefits to the firm (Porter & Kramer, 2006; Graafland et al., 2003), but also it is now clear that "a corporation can do well by doing good" (Kotler & Lee, 2005).

Nowadays, about seventy percent of publicly traded firms in the largest thirty-four countries adopt CSR (KPMG, 2011). However, a number of firms in fact engage in 'greenwashing' type of CSR. Nonetheless, there also exist firms that are more 'truthful' about their CSR engagement. We borrow from institutional theory, where CSR is considered as a part of a new legitimacy (Matten & Moon, 2008; Wood, 1991), to help us understand more. Our first study specifically studies the influence of institutional pressures on individual manager's attitude about CSR and on the different types of CSR activities firms undertake.

Empirical research on CSR thus far has focused almost exclusively on firms' responses towards external pressures and rarely considers internal pressures (Mayo et al., 2013). The hybrid framework we offer in the first study helps to contribute to the literature in the sense that neither external nor internal factors alone in its own right have the capacity to provide a full explanation of organizational behaviors.

The literature has identified, for instance, pollution prevention strategies and environmental innovation as CSR with substance (Klassen & Whybark, 1999; Russo & Fouts, 1997; Hart, 1995). This leads to the second and the third paper of this dissertation.

Businesses are being pressured to play a role in achieving *greening goals* alongside their *economic goals* (Elkington, 1994; Johnstone et al., 2008). Since one of the mechanisms for firms to deal with the changing environment is through innovations (Schoonhoven et al., 1990), environmental innovation presents itself as an appropriate option to deal with this mounting pressure and changing environment (De Marchi, 2012; Johnstone et al., 2008). In the second paper, we study the relationship between knowledge sourcing and firm's environmental innovation. In the last paper, we examine the impact of environmental innovation on employment.

As of this moment, the study on environmental innovation is still scarce (Chang, 2011; Horbach, 2008; Toshi et al., 2007). With the second study, we help shed light on firms' environmental innovation search strategy, specifically on where firms seek knowledge from and the importance of each knowledge source for firms of different sizes. As we analyze several knowledge sources together, we could access the degree of openness of firms' search strategies as well. We call it 'breadth' in this paper.

One of the topics commonly addressed during political debates concerns the question of how firms' transformations towards being green affect economic performance and employment (Rennings et al., 2004). Yet, the consequence of environmental innovation on employment is not particularly well-known and the views and impacts spur ongoing debate. With the third paper, we try to fill the gap by providing more empirical evidence at the firm-level. We analyze the impacts both in aggregate manner as well as of the different types of environmental innovation that exists. We decompose environmental innovation into voluntary and compliance-driven. Our study also has major policy implications, particularly on the design of micro-policies that will help to improve growth in employment.

Definition: Corporate social responsibility (CSR)

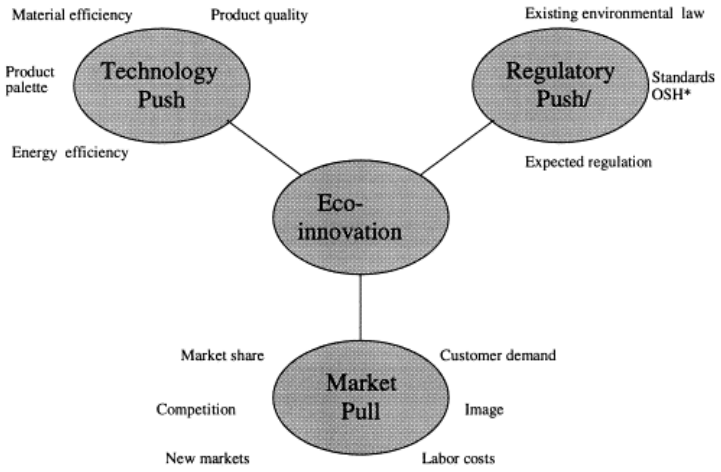
In this dissertation, the term CSR encompasses "economic, legal, ethical, and discretionary expectations that society has of organizations" (Carroll, 1979: 500). In essence, it involves conducting business in a way that is economically profitable, law abiding, ethical and socially supportive.

Definition: Environmental innovation

Environmental innovation is similar to innovation in general (van Leeuwen & Mohnen, 2013). Yet, unlike conventional innovations, technology-push and market-pull factors alone do not provide enough incentives for firms to be engaged in environmental innovation (Rennings, 2000). Environmental innovation produces the usual spillovers of innovations in general as well as creates less environmental costs. While the society as a whole benefits from environmental innovation, the cost is borne by a firm. Despite the fact that a certain green innovation can be marketed successfully, firms' ability to appropriate profits from such innovation can be difficult if the environmental benefits

have a public good character or the corresponding knowledge is easily accessible. Additionally, as long as the markets do not punish environmental harmful impacts, competition between environmental innovators versus non-environmental innovations is distorted. Market forces alone do not provide sufficient innovation incentives and that consumers' willingness to pay for environmental features would be too low. This is what Rennings (2000) calls 'double externality problem'. Consequently, this double externality problem leads to an increasing importance of regulatory framework since such externalities result in suboptimal investment in environmental innovations. Environmental policy becomes another important driving force for green innovations. See Figure 1.

FIGURE 1
A model of the determinants of environmental innovation



Source: Rennings, 2000

The terms eco-innovation, environmental innovation and green innovation have been and are still used synonymously (Tietze et al., 2011). In this dissertation, we adopt the definition below.

> "Environmental innovations consist of new or modified processes, techniques, practices, systems and products to avoid or reduce environmental damage. Environmental innovations may be developed with or without the explicit aim of reducing environmental damage. They also may be motivated by the usual business goals such as reducing costs or enhancing product quality. Many environmental

innovations combine an environmental benefit with a benefit for the establishment or user" (Hemmelskamp, 1997; Rennings, 2000; Rennings et al., 2004: 376).

Conclusion

Through the three papers on CSR and environmental innovation, we hope to provide new insights into how firms can deal with CSR and environmental innovation in this modern economy where there is a heightened demand for firms to behave not only in a socially responsible manner, but also in environmentally-friendly manner, approaching sustainability.

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CHAPTER 1
Institutional pressures and CSR attitude as determinants of CSR choices

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This paper reports research on the influence of institutional pressures and individual manager's attitude about corporate social responsibility (CSR) on the different types of CSR activities firms undertake. The data was taken from questionnaires sent to publicly-listed firms in Thailand and US, UK and Japanese subsidiaries of publicly-listed firms abroad that are currently located in Thailand. This paper argues that CSR programs can fall along a continuum between two endpoints: symbolic CSR and substantive CSR. The results indicate that mid-level managers experienced (1) negative attitude about CSR when pressured by external actors, inducing firms to adopt symbolic CSR; and (2) positive attitude about CSR when pressured by internal actors, influencing firms to adopt substantive CSR.

1.1 Introduction

Corporate social responsibility (CSR) of business encompasses "economic, legal, ethical, and discretionary expectations that society has of organizations" (Carroll, 1979: 500). It involves conducting business in a way that is economically profitable, law abiding, ethical and socially supportive. In today's world, of the hundred largest companies in each of the 34 countries, about seventy percent of publicly traded companies adopt CSR. European companies continue to lead the pack, with 71%, while Asia Pacific continues to trail behind, with 49% (KPMG, 2011). However, a number of firms are in fact engaging in 'greenwashing' type of CSR. Nonetheless, there also exist firms that are more 'truthful' about their CSR engagement. Thus, it is proposed in this study that CSR program configuration lies on a continuum with a CSR position at the two opposing end points – symbolic CSR and substantive CSR. Our interest lies in the determinants leading firms towards a symbolic CSR versus substantive CSR. Assuming substantive CSR can be riskier and more expensive since it entails higher costs and involvement, and greater potential exposure to coming up short in terms of meeting expectations from institutions, firms might then be naturally drawn to the symbolic choice – assuming a lower downside risk. Accordingly, our objective is to empirically examine the interrelationships of the determinants – institutional pressures and managers' individual attitudes towards CSR – that would help explain the variations in firms' CSR adoption. We hypothesize that firms' different approach towards CSR are affected by different institutions which influence mid-level manager's attitude towards CSR.

The research extends not only CSR literature but also institutional theory. The research extends the literature on CSR by exhibiting interactions between institutional pressures and individual managers' CSR attitude that influence the nature of CSR firms adopt. Empirical research on CSR has focused almost exclusively on a firm's responses to external pressures and rarely considers internal pressures (Mayo et al., 2013). In contrast, we study both the external and internal factors. The hybrid framework we propose is motivated by the complementary nature of both external and internal factors and it is relevant since neither external nor internal factors alone in its own right have the capacity to provide a full explanation of organizational behaviors. In this way, we could offer a more holistic view that helps to provide a solid platform for understanding the determinants of firms' approach towards CSR adoption. The research further

extends the field by examining the impact of cross-national context on firms' CSR practices where research is still scarce and there are many important implications (i.e., Matten & Moon, 2008; Maignan & Ralston, 2002). We also contribute empirically to this field by conducting research in the region where research and data are almost non-existent. Some research on country-level CSR in Thailand has been conducted, but there are still not many company-level analyses on CSR practices of Thai firms. The research also adds to institutional theory by encompassing both supra-individual bodies and interactions among individuals together, where the latter is often neglected in studies based on neo-institutionalism (Selznick, 1996). In this manner, we are able to incorporate the multi-level nature of institutions in our model as institutions operate at many levels from world system to interpersonal interactions (Scott, 2007). Additionally, instead of studying the influence of institutions on CSR at aggregated level, treating all constituencies as essentially a homogeneous block like most previous research studies, we divide institutions into different groups so we could have a clearer picture of the effects of different institutions on CSR.

In Thailand, about 35% of firms just learnt about CSR, 50% have launched some activities and 15% showed impressive progress (Yodprudtikan, 2009). CSR dimensions commonly addressed are labor, human rights, environment and governance issues (Prayukvong & Olsen, 2009). There exist both green-washing trend (Prayukvong & Olsen, 2009) and a more substantive version of CSR (CSR Asia Center at AIT, 2010). However, all in all, most firms see CSR as beneficial especially in terms of building good will and community trust. Firms often engage in CSR activities that consist of philanthropy and employee volunteering. A report by the Association of Thai Registered Companies in 2008 showed that 80% of publicly-listed firms' CSR activities were donations to charities. This unique CSR characteristic is influenced by the social/religious context in Thailand where performing good deeds is the basis of Buddhist merit-making culture. Another factor contributing to this is Thai people's enormous amount of respect and devotion towards its monarch, who has set up numerous royal foundations to assist the poor (Prayukvong & Olsen, 2009), triggering firms to donate to these foundations to show supports to His Majesty the King's initiatives. Multinational companies in Thailand are also aligning their global CSR activities with local CSR concepts (Prayukvong & Olsen, 2009). However, despite significant efforts to build CSR awareness through several approaches, Thai firms still have a limited knowledge on CSR essence and practices (Prayukvong & Olsen, 2009).

The research is based on a survey of 174 firms that are Thai publicly-listed firms and foreign subsidiaries of firms listed in New York, London and Tokyo stock exchanges. Our study is limited to only publicly-held firms as they are subjected to greater public scrutiny, prompting greater social responsiveness (McWilliams & Siegel, 2001; Waddock & Graves, 1997; Carroll 1991; Pfeffer & Salancik, 1978). The results indicate that neither external nor internal institutional pressures alone have significant relationships with symbolic or substantive CSR. Instead these forces display an effect through CSR attitude of individual managers, which successively, induce them to make differing decisions pertaining to types of CSR to be involved in. CSR attitude mediates the relationship between (1) external institutional pressure and symbolic CSR, and (2) internal institutional pressure and substantive CSR. The results also show that ethical education and ethical training are factors that influence a more socially responsible behavior.

The paper proceeds as follows. We briefly discuss the literature on CSR and how managers affect the nature and outcomes of CSR. Then, we continue on to proposals of hypotheses, the results and future research.

1.2 Theoretical background and hypotheses

1.2.1 CSR continuum: Symbolic CSR versus substantive CSR

A failure to distinguish among different types of CSR can result in much of the confusion because varying structures of CSR programs can be found today (Pirsch et al., 2007) due to varying CSR tactics used by companies and a multi-dimensional nature of CSR construct that encompasses diverse aspects (Waddock & Graves, 1997; Carroll, 1979). Institutional theory identifies two general types of organizational responses to institutional pressures – symbolic and substantive (Oliver, 1991; Ashforth & Gibbs, 1990, Meyer & Rowan, 1977). We thus propose that CSR programs can fall along a continuum between the two endpoints of symbolic CSR and substantive CSR.

Sansiri, a publicly-traded real estate developer who positions itself as a premium developer, adopts what this paper terms a symbolic CSR. Symbolic activities are "actions in which the actor displays or tries to draw other actors' attention to the meaning of an object or action that goes beyond the object's or action's intrinsic content or functional use" (Zott & Huy, 2007: 70). Sansiri pretends to appear socially

responsible by forging with UNICEF to raise awareness for children's rights (Sansiri, 2013) while it behaves irresponsibly, ignores the safety of its consumers and violates law by substituting concrete with foam in its building (Bangkok Post, 2013). If Sansiri's client had not torn down his wall to fix the continuous water leak, Sansiri would have achieved in taking up good causes of helping children to project a 'good image' because the firm has recently received 'Best CSR Practice across Southeast Asia' award in 2011 (Sansiri, 2013). In sum, symbolic CSR represents ceremonial conformity (Weaver et al., 1999), involves weaker commitments such as short-term cause sponsorship programs, and is a decoupled implementation from core practices (Berrone et al., 2009). The final goal is to influence societal perceptions by using more visual actions rather than substance in order to obtain benefits (Berrone et al., 2009) such as legitimacy, greater appeal, and increase in sales from better reputation. Symbolic CSR is in essence impression management. Firms engaged in CSR of this nature are more concerned with corporate benefits rather than to genuine concerns for societies (Pirsch et al., 2007).

At the other end of the spectrum, Siam Cement Group (SCG) provides an excellent example of firms that is engaged in what this paper calls substantive CSR. SCG develops sustainable policies with substance, that is, with goals, measurement and implementation guidelines for each of its business units. SCG also places importance in producing innovative products that are both environmentally friendly and meet the demands of the consumers. Environmental labeling, such as Green Label, Carbon Label, Carbon Footprint Label, is one of the tools that SCG uses (SCG, 2013). The literature has identified, for instance, pollution prevention strategies and environmental innovation as CSR with substance (Klassen & Whybark, 1999; Russo & Fouts, 1997; Hart, 1995). Further, substantive CSR also involves the use of renewable energy, green technologies, and long-term CSR projects with specified goals and measurements. Unlike symbolic CSR, substantive CSR are real actions that often requires changes in core practices and organizational culture, long-term commitment and investments (Eccles et al., 2013) and entails certain risks (Berrone et al., 2009). In this way, CSR options for companies operate on a continuum, with symbolic CSR companies at one end of the spectrum and substantive CSR programs at the other end.

1.2.2 Institutional salience and CSR

A central tenet of institutional theory, despite old, new, institutional entrepreneurship, institutional work, is the idea that there are institutions that have a profound effect on the thoughts, feelings and behavior of collective actors as well as individuals (Lawrence & Suddaby, 2006). Collective actors such as firms conform to rationalized myths in their institutional environment in order to obtain legitimacy, resources and survival capabilities (Selznick, 1996; Meyer & Rowan, 1977). Particularly firms are predicted to conform even more when these 'myths' are so externally accepted and validated (DiMaggio, 1988) or when these 'myths' render the only 'obvious' approach to conduct organizational activities (Zucker, 1987). Thus, institutional pressures lead firms to adopt similar structures, strategies and processes – or what instituttional literature calls "organizational isomorphism" (DiMaggio & Powell, 1983) – that reflect institutionalized elements without any questions (Meyer & Rowan, 1977). As institutions are exerting pressures on firms to execute CSR, firms are increasingly adhering to socially responsible behavior as a way to satisfy institutional demands (Matten & Moon, 2008; Weaver et al., 1999).

Institutions operate at multiple levels, from world system to interpersonal interaction (Scott, 2007). We therefore split institutional pressures on firms to embrace CSR into external and internal institutional actors. In this manner, we could capture normative pressures – from both external sources such as the state and from within the firm – that influence firms' behaviors (Selznick, 1996; Zucker, 1987) as well as encompass both world system aspects of the theory and interactions among individuals into our model. Our external institutions are supra-individual bodies operating outside firms at the macro-level within which firms maneuver (DiMaggio & Powell, 1983) such as government. Our internal institutions are interactions among individuals inside firms such as employees, management (Campbell, 2007). There are other factors triggering firms to respond differently to CSR as well, for instance, the features of the social problems. However, it is beyond the scope of this paper to discuss triggers other than varying pressures from different institutional actors.

Even though institutional pressures do direct firms' behavior towards homogeneity, there are still complexities and variety of organizational responses in order to shape the 'best' organizational practices (Powell & Colyvas, 2007). Institutional forces merely define 'the range of organizational reality' and limit 'the

repertoire of possible actions' (Hoffman, 1997), allowing for differences in strategies among individual companies (Sharma, 2000). As a result, specific CSR initiatives are more or less appropriate for certain firms (McWilliams et al., 2006). Previous research confirm this argument, showing how firm responses towards CSR vary greatly (Oliver, 1991), particularly across countries with differing institutional environment (Maignan & Ralston, 2002).

From institutional theory stance, symbolic actions are effective responses to external pressures (Meyer & Rowan, 1977). Symbolic CSR is likely to be a preferred choice as "the appearance [of conformity] is often presumed to be sufficient for the attainment of legitimacy" (Oliver, 1991: 155) and making firms easy to insulate themselves from external expectations (Weaver et al., 1999). For instance, Weaver et al. (1999) found that governmental pressure begets firms to implement symbolic CSR. On the contrary, some firms find substantive CSR the right vehicle to implement as there is no penalty or destructive impact from allocating resources to CSR (Waddock & Graves, 1997). In fact, such investments are actually advantageous (Hillman & Keim, 2001; McWilliams & Siegel, 2001; Russo & Fouts, 1997; Waddock & Graves, 1997). Weaver et al. (1999) reported that managers are an essential part to what drives organizations to be involved in a more substantive version of CSR. In sum, in responding to these external and internal pressures, firms have the option to engage in either symbolic or substantive CSR.

From the above arguments, if we are to accept that firms adopt two main CSR choices – symbolic and substantive – then we should also expect that such choices cater to specific, yet different, institutions. Accordingly, we posit the following hypotheses:

> *H1a: External institutional pressures are positively related to symbolic CSR.*
> *H1b: Internal institutional pressures are positively related to substantive CSR.*

1.2.3 Managers, attitudes and CSR

Concerning CSR, managers matter because "there cannot be socially responsible firms without socially responsible managers" (Godos-Díez et al., 2011: 531). Top managers are charged with strategy making and then organizing middle management for precise planning and components implementation of such strategy (Dutton et al., 1997). It is often middle managers, rather than top managers, who have their hands on the

actual 'pulse of the organization' (Dutton et al., 1997), closer to day-to-day operations and closer to employees, customers and all other stakeholders involved (Huy, 2001). For instance, it is more common to see CEOs setting up directions for firms to be socially responsible and to see CSR managers at a tree-planting CSR event. In this regard, middle managers are crucial towards the implementation of CSR.

Drawing from Upper Echelon (UE) theory, managers lead and managers rely on their cognitive bases when making decisions (Hambrick & Mason, 1984). This cognitive base, which is a part of what forms an attitude of a person (Zanna & Rempel, 1988), is what influences managers' interpretations of the issues, facilitating them to make certain choices (Hambrick & Mason, 1984). Likewise, as suggested by Dutton and Jackson (1987) and Tversky and Hemenway (1983), individuals employ schema – organizing objects into meaningful groups – in order to categorize information. For a straightforward issue of physical objects like how much output the new machine is going to produce, individuals can easily observe and allocate the issue to pre-determined categories. But for societal phenomena like CSR that presents individuals with ambiguity, individuals draw on their cognition to help identify categorizations (Dutton & Jackson, 1987; Tversky & Hemenway, 1983). As a result, attitude particularly matters for ambiguous issue like CSR.

Besides from institutions having influence on firms' CSR behaviors (Margolis & Walsh, 2003; Maignan & Ralston 2002), pressures from these institutions do affect attitudes of managers as well (Lawrence & Suddaby, 2006). Assessment of external environment has an objective base, i.e., through industry analysis, but also is influenced by subjective perceptions of individuals inside the firm (Schneider & Meyer, 1991; Daft & Weick, 1984). Responding to external demand to instigate CSR could create a perception of a 'forced compliance (Festinger, 1957)'. If displaying such behavior is brought about by, say, threats of punishment from decreased firm legitimacy by institutional environment, the magnitude of dissonance is increased, and in such state, individuals may feel frustration, anger, etc (Festinger, 1957). It can then be expected that negative attitude is created. On the contrary, in the case of internal pressures, the processes in the firms are set in a way to promote CSR. For instance, top management includes socially responsible behavior as part of firm's core value or integrates CSR goals and strategies into core business strategy. A structure and culture would be developed that hold workers committed to CSR and seeing it as having value. Particularly, managers responsible for CSR then know they would receive support from

above and below. It is then likely that this would lead to a more positive CSR attitude in managers.

Since attitude triggers different decision processes and behaviors (Nutt, 1979; Dutton & Jackson, 1987), CSR attitude may mediate the basic relationship between institutional pressures and the approach towards CSR that firms adopt. We conjecture that institutional forces affect CSR attitude of managers, which successively, influences certain approach towards CSR managers consider and engage in. We propose the following hypotheses:

H2a: External institutional pressures are negatively related to managers' CSR attitude.
H2b: Internal institutional pressures are positively related to managers' CSR attitude.

H3a: Managers' attitude towards CSR is a mediating variable affecting the relationship between external institutional pressures and symbolic CSR.
H3b: Managers' attitude towards CSR is a mediating variable affecting the relationship between internal institutional pressures and substantive CSR.

1.3 Methodology

1.3.1 Data and procedures

The sample was taken from a list of publicly traded firms in Thailand and foreign subsidiaries (located in Thailand) of publicly traded firms in the US, UK and Japan. The cover letter and questionnaire were distributed to middle managers and/or employees who are responsible for or have the most knowledge of CSR of their firms. The respondents could choose if they wanted Thai or English questionnaire. This is to ensure that concepts are appropriate and valid in cultures under investigation and to reduce misunderstandings in responses because some respondents may be more comfortable in one language over another. Details of the survey administration are contained in Appendix A.

Of 1,100 questionnaires distributed to the total population, 174 completed questionnaires were returned for a response rate of 15.81%: 42.6% Thai firms (74 firms)

and 57.4% foreign subsidiaries (34 US, 17 UK and 49 Japanese subsidiaries). These firms operate in several sectors as reported in Table 1.

TABLE 1
Industry and firm's country of origin

Countries	Industry									
	Agro & Food industry	Consumer products	Financials	Industrials	Property & construction	Resources	Services	Technology	Electric appliances	**Total**
US	1	5	.	11	.	1	9	6	1	**34**
UK	1	2	3	2	.	1	7	1	.	**17**
Japan	1	4	.	17	3	.	12	5	7	**49**
Thai	7	3	8	11	15	4	17	9	.	**74**
Total	**10**	**14**	**11**	**41**	**18**	**6**	**45**	**21**	**8**	**174**

From our sample, 88% of these firms are currently engaging in CSR programs. For firms that are doing CSR, 94% reported that they are highly likely to continue with their CSR projects, 79% are satisfied with their CSR results, and 85% have financial resources allocated for CSR projects. These firms mostly spend 0-1% of net income on CSR projects. For firms that are not currently engaged in CSR, 88% reported they are planning for CSR, mostly within 1-3 years. Firm's two most important stakeholders are community/state welfare (58%) and employees (17.5%). More information is reported in Table 2.

TABLE 2
Firm's important stakeholders

Community/state welfare	58.48%
Employees	17.54%
Shareholders/investors	12.87%
Customers	10.53%
Suppliers	0.58%

It is interesting to note that most firms (77%) offer ethical training to employees, with the average of one ethical training per year. Of all firms in our sample, 65% of all

Japanese subsidiaries provide ethical training for their employees while it is 76% for US subsidiaries, 94% for UK subsidiaries, and 81% for Thai firms.

1.3.2 Respondents

Our respondents perform a wide range of business functions. They are, for example, CSR managers, human resources mangers, marketing managers, and brand managers. The majority of respondents are of Thai nationality (97%). The rest is one British, one Chinese, one Japanese, and one US citizen. Most respondents (92.49%) reported having previously received ethical education, with the average of 3-6 years of ethical education.

1.3.3 Measures

Measures: Institutional pressures

The respondents were asked what the most important motivation for the firm to engage in CSR was. The results report pressures from top management as the strongest force (33.53%), followed by society (25.15%) and other organizations (14.97%). The lowest level of pressure came from shareholders with only 1.20%. No option for 'no internal' or 'no external' was available. We also did not include all the possible institutional actors in the questionnaires, only the most relevant and influential ones to our context. For example, we did not include unions as they are not powerful and do not really exist in Thailand, nor did we include NGOs. We grouped top management, employees and shareholders together using dummy of 1 as internal institutional pressures and 0 otherwise. We then grouped competitors, community at large, government and other external pressures (i.e., industry trend) using dummy of 1 as external institutional pressures and 0 otherwise.

Measures: CSR attitude

The attitude towards CSR we study here refers to a belief in socially responsible behaviors of the firms. It is managers' 'personal view' of CSR of their firms. We adopted the scale developed by Hunt et al. (1990) to measure the extent to which

individuals hold beliefs that firms have duties to serve not only firms but also society. The items were averaged for each respondent with higher composite score representing a stronger belief in the importance of businesses to engage in CSR activities. We adapted from a 7-point to a 9-point Likert scale in order to increase scale sensitivity while maintaining reliability and validity of the original scale (Preston & Colman, 2000). We also removed a reversed-worded item. East Asians experience positive and negative emotions in a more holistic manner rather than in a bipolar manner (Bagozzi et al., 1999). A mixed-worded Likert scale (positively-worded versus negatively-worded) would be problematic and result in lower internal consistency and dimensionality problem (Wong et al., 2003). We re-ran the analysis using factor analysis (principal-component method) to compare the results of both the original scale of four items and the reduced scale of three items. The adjusted scale of three items resulted in an improvement. The final three items are: (1) socially responsible manager must occasionally place the interests of society over the interests of the company; (2) as corporations have great economic power, they have a social responsibility beyond the interests of their shareholders; and (3) as long as corporations generate acceptable shareholder returns, managers have a social responsibility beyond the interests of shareholders.

Measures: CSR continuum

In order to operationalize the two differing concepts along the CSR continuum, twelve statements were used to inquire respondents about their perceptions on current and future CSR projects. These items were compiled from existing literature, experts and practitioners in business fields to ensure content validity. Items were placed randomly in a single set to (1) reduce the likelihood of a halo response pattern (Thorndike, 1920) and (2) to find out how managers take an approach towards CSR programs in terms of deciphering from CSR behaviors. Our items address diverse but broad CSR issues. Different social issues are of varying concerns to different institutional environment. The degree and types of social issues businesses should address also change with time as societal values (Preston & Post, 1975). Therefore, we designed these statements to be general in order to capture a distinct nature of CSR construct that is multi-dimensional (Carroll, 1979).

We used factor analysis (principal-component method and rotation) to identify latent variables. Before performing factor analysis, we tested if the items were suitable using KMO and Bartlett tests. The results indicated that a factor analysis was a good idea (KMO = 0.89; Bartlett: p-value 0.00). Two factors were clearly identified as expected, accounting for 64.63% of the common variance.

Previous studies have operationalized symbolic and substantive actions based on the degree of implementation (Westphal & Zajac, 1994). However, given the difficulties in separating the degrees of implementation in CSR context, scholars use an alternative way of measuring symbolic and substantive actions based on widely held beliefs and definitions of what is symbolic and what is substantive (Hawn & Ioannou, 2013; Berrone et al., 2009). In this regard, we labeled the first factor substantive CSR. This factor highlights the point that it is CSR with substance, that is, with specified goals and measurements, with genuine commitment and deeply-integrated with core business and day-to-day operations. The component is correlated with statements such as "are well integrated into all aspects of firms (factor loading 0.76)", "have met objectives previously specified before initiating CSR programs (factor loading 0.84)" and "increase the well-being of beneficiaries of those CSR programs(factor loading 0.74)." We labeled the second factor symbolic CSR. CSR components of this type are cosmetic, decoupled, and often aimed for media coverage and public relations to publicize that I am a good corporate citizen (Porter & Kramer, 2006). Studies have found that symbolic actions can still yield the desired effect of appearing conformed to institutional demands (Weaver et al., 1999); thus, entitling corporate with benefits (Berrone et al., 2009) such as enhanced social acceptance, positive public relations (Hemingway & Maclagan, 2004) or increase in sales from better reputation or higher consumer loyalty (Pirsh et al., 2007). The factor is correlated with statements such as "increase in direct economic value (i.e., sales) generated by CSR programs (factor loading 0.86)" and "receive a satisfactory level of media coverage (factor loading 0.68)."

Control variables

CSR practices are conditioned by characteristics of firms and managers (Godos-Díez et al., 2011; Hillman & Keim, 2001; Waddock & Graves, 1997) as well as CSR characteristics (McWilliams & Siegel, 2001); hence, we included these factors as control variables to add precision to our model.

First, we included industry, size, country and ethical training as controls for firm's characteristics. Industry was included to ensure that differences in types of CSR engagement are not merely an effect of industry differences. In this paper, industry dummies were coded as categorized by the stock exchange of Thailand. Size was included because there is evidence that larger firms exhibit more overt socially responsible behaviors than smaller firms (McWilliams & Siegel, 2001; Waddock & Graves, 1997; Carroll, 1991), and therefore, might affect the nature of CSR involved, for instance, simple donation for smaller firms for symbolic purpose versus fully-integrated CSR for purpose with substance for bigger firms. Firm size was measured using logarithm of total revenues of 2011 taken from the annual reports and Thai government database. A country's culture and ideology affect behavior (Hofstede & Hofstede, 2005); thus, country dummies were also included. We expect country to have an effect on the differing preferences for CSR types. A dummy of whether ethical training is offered by firms was also included because firms' ethical trainings affect employees' socially responsible behaviors (Graafland et al., 2003).

Second, we included a dummy of a respondent having previously received ethical education or no ethical education as control. Ethical education forms a part of personal characteristics that affect moral reasoning processes, which in turn, influence socially responsible behaviors (Goolsby & Hunt, 1992). Likewise, formal training in moral philosophy shapes the processes through which individual ethical decisions are made (Graafland et al., 2003; Goolsby & Hunt, 1992); consequently, making particular CSR activities appear more preferred than others.

Third, Lantos (2001) stated that certain characteristics of firms' CSR influence CSR practices; therefore, we controlled for whether a firm has financial allocation for CSR along with a dummy stating whether a manager's performance evaluation is tied to CSR or not.

1.4 Results

Aggregation

Table 3 and Table 4 report Cronbach's α and results of a factor analysis in this study. Our constructs all have Cronbach's α above 0.7; therefore, they are considered reliable (Hair et al., 1998). Our constructs are also unidimensional. The variance

inflation factors (VIFs) are in the range of 1.06-6.19 with the mean of 2.36, which are below the threshold of 10, indicating no evidence of multicollinearity.

TABLE 3
Cronbach's α coefficients of the constructs

Constructs	Number of items	Cronbach's α
CSR attitude	3	0.70
Symbolic CSR	4	0.78
Substantive CSR	8	0.92

TABLE 4
Factor analysis of this study

Constructs	Number of items	Number of factors	Accumulation percentage of explained variance (%)
CSR attitude	3	1	62.15
Substantive CSR	8	1	64.60
Symbolic CSR	4	1	61.40

The descriptive statistics and correlation matrix for the main variables are presented in Table 5. It is interesting to note that internal and external institutional pressures are not significantly correlated with either symbolic CSR or substantive CSR, whereas CSR attitude is significantly correlated with internal and external pressures (r = 0.17, $p < 0.05$; r = -0.17, $p < 0.05$) and symbolic CSR and substantive CSR (r = 0.16, $p < 0.05$; r = 0.14, $p < 0.10$). Concerning control variables, firm size, ethical training, ethical education and CSR allocation are positively correlated with substantive CSR (r = 0.19, $p < 0.05$; r = 0.27, $p < 0.01$; r = 0.12, $p < 0.01$; r = 0.26, $p < 0.01$) while only ethical education is positively correlated with symbolic CSR (r = 0.19, $p < 0.05$). Firm size is also positively correlated with firm's financial allocation for CSR (r = 0.23, $p < 0.01$), consistent with theoretical and empirical work by McWilliams and Siegel (2001), Waddock and Graves (1997) and Carroll (1991). Interestingly, managers' incentive tied to CSR does not correlate with any variables. A plausible explanation can be that most respondents answered no to this question.

TABLE 5
Descriptive statistics and correlation matrix

Variable	1	2	3	4	5	6	7	8	9	10
1. Symbolic CSR	1									
2. Substantive CSR	0.63*	1								
3. Internal pressure	-0.06	-0.03	1							
4. External pressure	0.06	0.03	-1*	1						
5. CSR attitude	0.16*	0.14†	0.17*	-0.17*	1					
6. Firm size	0.09	0.19*	0.09	-0.09	0.01	1				
7. Ethical training	0.09	0.27*	-0.04	0.04	0.05	0.1	1			
8. Ethical education	0.19*	0.22*	0.06	-0.06	-0.09	0	0.08	1		
9. CSR allocation	0.11	0.26*	0.11	-0.11	-0.1	0.23*	0.03	0.02	1	
10. Managers' incentive tied to CSR	0.04	0	0.12	-0.12	0.11	0.04	0.12	0.01	0.06	1
Mean	1.88e-10	-2.34e-9	0.41	0.60	5.62	4.47	0.77	0.92	0.79	0.09
S.D.	1	1	0.49	0.49	1.57	2.50	0.42	0.26	0.41	0.28
Minimum	-2.57	-3.68	0	0	1.67	-4.18	0	0	0	0
Maximum	2.27	1.49	1	1	9	11.30	1	1	1	1

†$p < 0.10$, * $p < 0.05$
n = 174

Test of hypotheses

To test the hypotheses, we performed hierarchical regression (with robust). This allows us to examine the influence of several predictors in a sequential way. The usual procedure used when examining the presence of mediation requires three regression equations: (1) the dependent variable is regressed on independent and control variables (Model 1), (2) the mediating variable is regressed on independent and control variables (Model 2), and (3) the dependent variable regressing on independent, mediating, and control variables (Model 3) (Baron & Kenny, 1986). However, contemporary analysts (i.e., MacKinnon et al., 2007; Kenny et al., 1998) express that the significance of independent variable in Model 1 is not required since the relationship is implied if Model 2 and Model 3 are met. MacKinnon et al. (2007) refer to this as *inconsistent mediation*. The results of regression analysis in this study are shown in Table 6 and 7. Additionally, robustness checks, using other regression method (GLM) and different proxy for some control variables, did not change the results.

TABLE 6
Regression results of external pressures

	Symbolic CSR Model 1a	CSR attitude Model 2a	Symbolic CSR Model 3a
External	0.2390	-0.5380*	0.3319*
CSR attitude			0.1432**
Constant	-1.7606**	5.2689**	-2.5368**
Controls:			
Firm size	0.0824†	0.0326	0.0806†
Eth training	0.1229	0.0663	0.1036
Eth education	0.9058**	-0.6000	0.9890**
CSR financing	0.2076	-0.3708	0.2694
Managers' incentives	0.2438	0.8219*	0.1375
Industry dummies	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes
R^2	0.14	0.14	0.19
F	1.70*	2.44**	2.45**

TABLE 7
Regression results of internal pressures

	Substantive CSR Model 1b	CSR attitude Model 2b	Substantive CSR Model 3b
Internal	-0.1409	0.5380*	-0.2121
CSR attitude			0.1240*
Constant	-2.1086**	4.7309**	-2.6767**
Controls:			
Firm size	0.0611	0.0326	0.0556
Eth training	0.6158**	0.0663	0.6019**
Eth education	0.7949*	-0.6000	0.8699**
CSR financing	0.5549*	-0.3708	0.6032*
Managers' incentives	-0.1643	0.8219*	-0.2708
Industry dummies	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes
R^2	0.22	0.14	0.25
F	2.45**	2.44**	2.87**

Hypotheses 1a and 1b predict that external pressures are positively related to symbolic CSR and internal pressures to substantive CSR. Coefficients of institutional pressures in Model 1a and 1b are insignificant; therefore, both hypotheses are not supported.

The second set of hypotheses posits that external pressure is negatively related to individual managers' CSR attitude while internal pressure is positively related. For external pressure as independent variable (Table 6), the coefficient for CSR attitude in

Model 2a is significant and the direction is as hypothesized (β = -0.5380, $p < 0.05$). In Model 2b, the result shows that internal pressure is positively related to CSR attitude of individual managers. Support is found for Hypotheses 2a and 2b. Thus, the first necessary condition for a mediating effect to exist is fulfilled.

Hypothesis 3a states that CSR attitude of managers mediates the relationship between external institutional pressures and symbolic CSR. The coefficients for external pressure (β = 0.3319, $p < 0.05$) and CSR attitude (β = 0.1432, $p < 0.01$) in Model 3a are significant. The result indicates a partial mediation and a support for Hypothesis 3a. For Hypothesis 3b (Table 7), the coefficient for CSR attitude (β = 0.1240, $p < 0.05$) is significant and positive but the coefficient of internal pressure is not significant, indicating a full mediation and a support for Hypothesis 3b.

We do not report total, direct nor indirect effect because Kenny (2013) suggests this measure should not be computed especially in the case of inconsistent mediation. Thus, we follow MacKinnon et al. (2002) and conducted Sobel test (Sobel, 1982) to determine the significance of a mediating effect. The test verifies significant mediation for both symbolic CSR (z = 1.89, $p < 0.10$) and substantive CSR (z = 1.7, $p < 0.10$). Though p values are not so low, we suspect a larger sample size would fix this as Sobel test is based on normality assumption, requiring large sample size in order to have sufficient power to detect significant effect. Ergo we did bootstrap, which is a more appropriate method for a small sample size (Preacher & Hayes, 2004). 95% bias corrected bootstrap confidence intervals (based on 1,000 bootstrap samples) concluded that the indirect effect is significant. Taken together, these results indicate that CSR attitude mediates the relationship between (1) external institutional pressure and symbolic CSR, and (2) internal institutional pressure and substantive CSR. We elaborate further in the discussion section.

1.5 Discussions

Our objective is to explore the impact of different institutional pressures and CSR attitude on the selection of choices for the types of CSR activities adopted by firms.

Our results show that institutional contexts lead to both firms' homogeneity and heterogeneity, consistent with Sharma (2000). Homogeneity in adopting CSR and heterogeneity in enacting differing CSR approaches along the CSR continuum proposed

in this paper. Our study reveals that firms do not respond in the same fashion to different sets of institutional pressures – internal versus external. Firms appear to be selecting between symbolic or substantive CSR. The study supports the fact that institutional forces indeed merely define the range of possible options for firms to adopt (Sharma, 2000; Hoffman, 1997). This is because firms are subjected to multiple and varying institutional influences rather than a common set of pressures (Sharma, 2000). The two types of actions, be it symbolic or substantive, have different effects. For instance, symbolic actions deter substantive actions and become a threat to firms' external legitimacy (Maclean & Behnam, 2010) and financial performance (Walker & Wan, 2012). On the other hand, CSR program of substantive nature creates consumer loyalty, intention to buy and positive attitude towards the firm (Pirsch et al., 2007). However, symbolic CSR is not without merit. A study by Pirsch et al. (2007) shows that consumers do indeed place value on even the most basic forms of CSR. It is merely that the positive impact of symbolic action on firms is short-term while substantive action lasts for both short-term and long-term (Berrone et al., 2009). For this reason, substantive CSR should be preferred. After all, firms exist because the institutional environment has set up necessary structures for them; therefore, firms have 'social contracts' that obligate them to treat institutions ethically and fairly in return (Cragg, 2002).

Our study also reveals that middle managers react differently to institutional pressures. External pressures produce negative attitude towards CSR among middle managers (Hypothesis 2a) while internal pressures instill positive attitude (Hypothesis 2b). Due to this, when external players demand CSR, managers can become defensive because they might feel attacked and they then become protective of themselves and their firms. Further, if there exists a misalignment between firm's orientation (not believing in CSR) and external expectation (expecting the firm to adopt CSR), it will lead to dissonance. Negative attitude is then can be expected. On the contrary, when internal institutions pressure for CSR, organizational structure and processes including corporate culture are set in a way to allow and promote CSR. In that case, firms would automatically prepare, organize, train, and motivate their internal workers to be ready and to embrace CSR. Thus, more positive CSR attitude in managers is created. The implication here is that not only that positive attitude helps in influencing satisfaction, involvement and commitment (Robbins & Judge, 2010), but positive attitude also would help overcome a barrier created when a new practice is adopted (Blackman et al., 2013).

A positive attitude is better than a negative attitude. Internal institutional pressure is indeed vital towards the creation of positive attitude among managers who are designated to implement CSR.

Further, though many multinational companies (MNCs) employ 'global CSR' initiated by head office, our results report insignificant country dummies, implying that institutional pressure from host country determines managers' CSR attitude. Our results are consistent with a study by Maignan & Ralston (2002), which illustrates that institutional environment of host country has stronger effect in shaping CSR attitude of workers than institutional environment of home country. Some aspects of CSR can be globalized, but it is still recommended that many dimensions of firms' CSR be localized to cater to local institutional environment and social issues at hand.

An interesting finding is how CSR attitude partially mediates the relationship between symbolic CSR and external pressures while CSR attitude fully mediates the relationship between substantive CSR and internal pressures (Hypotheses 3a and 3b). Neither external nor internal pressures alone have enough power to influence symbolic or substantive CSR. It is only through the mediation effect of CSR attitude. An explanation for this mediation is that conception and implementation are different things (Huy, 2001). Firms are increasingly dependent on mid-level managers (Dutton et al., 1997; Bartlett & Ghoshal, 1993) because they can spread words and get people on board. Senior managers have their own networks, of course, but they are too far removed from most workers (Huy, 2001). Middle managers indeed do play vital role in implementation. Managing them involves understanding about their values, preferences and attitudes toward particular activities (Linstone & Mitroff, 1994). Thus, their attitude, which influences commitment, satisfaction and involvement (Robbins & Judge, 2010), matters in turning vision into reality. In the case of negative attitude, as it does not lead to deep commitment or involvement (Robbins & Judge, 2010), the most likely response is symbolic actions that are easily decoupled, require less investment and/or are less risky. For example, a decision by CSR manager to do a one-time donation is less risky, requires less investment, and is enough to appear conformed to external demands. CSR actions are difficult for institutions to monitor and verify (Perez-Batres et al., 2012). In most cases, institutions can only assess a company's CSR based on their symbolic representations (Berrone et al., 2009). Adopting CSR of symbolic nature is sufficient for legitimacy attainment (Oliver, 1991). Positive attitude, on the other hand, is likely to result in substantive actions like developing environmental innovation, green

supply chain, CSR with specific goals and measurements, etc. Our study empirically confirms that for institutionalization to take shape, the process of institutionalization starts with institutions influencing attitude of individuals which then is transformed into adoption of practices (Gavetti & Levinthal, 2000), which in this case is CSR. This indicates that stronger internal pressure is needed to instill a more positive attitude towards CSR in managers and subsequently the adoption of a more comprehensive and expansive CSR programs.

Another interesting finding is that ethical education is positive and significant to both types of CSR as expected. Ethical education introduces virtues and morality in individuals' decision-making (Carroll, 2000), which in turn, influences socially responsible behaviors. Thus, a consideration to implement any types of CSR at least requires some ethical concerns, impregnated through ethical education. Similarly, ethical training positively influences substantive CSR but not symbolic CSR. Since ethical trainings foster ethical behaviors in firms (Graafland et al., 2003), more ethical trainings provided to employees would fabricate more ethical behaviors, producing stronger commitment and more genuine interest in CSR. Thus, this would lead to an engagement in substantive CSR rather than symbolic CSR.

We recognize some limitations of our approach to measuring our constructs. We used composite subjective indexes based on survey data. The nature of the topic and the use of self-report surveys could provoke social desirability bias and percept-percept inflation. Though we employed several methods such as using forced-choice items (Nederhof, 1985) and supplementing subjective data with secondary data, a better alternative could be to develop more objective measures of these constructs. We also note a potential challenge in measuring managers' personal view of CSR and CSR approaches when the field still lacks consistent definition (McWilliams et al., 2006). It is then difficult for respondents to fully understand CSR; therefore, an observational and longitudinal type of approach on firms' CSR behavior can be more appropriate. Furthermore, another limitation we would note is our use of cross-sectional methodology, which did not allow full examination of the effect of external pressures on internal pressures. It can be argued that external pressures influence internal actors, and subsequently, generating certain internal pressures. Careful interpretations of results are needed as we only captured internal pressures as a given at a point in time when research was conducted.

As such, this study presents us with several possibilities for future research and theoretical and empirical refinement on CSR and institutional theory. First, this study examines firms' adoption of CSR practices of large publicly-traded firms only. However, small and medium-sized and privately-held companies do play critical roles in the societies as well. It would be beneficial to replicate the research and compare privately-held firms with publicly-traded firms so we could gain a richer understanding of the topic. For example, are there any differences in the relationships found in this study for privately-held firms or do privately-held firms respond differently to institutional pressures than publicly-held firms? Second, this study did not take into account the varying level of intensity of institutional pressure on firms. It will be very interesting to see at which degree institutional pressure actually triggers firms to be engaged in CSR. Third, this study is limited to only the two opposite ends of the CSR continuum. An empirical development of finer scale of CSR continuum would have important implications on firms. Such study would offer firms insights into the different CSR strategies firms can adopt. In addition, a finer categorization of different types of institutional actors and/or other sources of institutional pressures would help practitioners and researchers alike to understand this complex relationship better. Lastly, as CSR varies considerably among countries due to variations in national systems (Chapple & Moon, 2005), a replication in other settings, possibly in very different national and cultural settings, is worthy of further research.

1.6 Conclusion

For firms and their managers, one of the many dilemmas they face is in choosing the most appropriate approach towards CSR in order to meet business goals and social expectations (Pirsch et al., 2007) in their institutional environments. This study seeks to provide an answer to this question by providing insights about the complexity of several factors that influence the selection of firms' CSR approach. The responses provide an answer to what leads to the two proposed endpoints of the CSR continuum: symbolic CSR and substantive CSR. The results reveal that the resulting firm's decision to adopt either symbolic or substantive CSR is influenced by different sets of institutional pressures and CSR attitude of individual managers. Middle managers experience negative attitude towards CSR when pressured by external institutions, inducing firms to adopt symbolic CSR. On the contrary, pressures from internal institutions instill

positive attitude in managers, influencing firms to adopt substantive CSR. The novelty of our study is that not only are we able to show there exist institutional influences on CSR practices, but we are also able to shed some light on how different types of institutional pressures affect managers' attitude towards CSR and CSR practices. This study hopes to provide new insights into how firms can deal with CSR in this modern economy where there is a heightened demand for firms to behave in a socially responsible manner.

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1.8 Appendix A

In order to test the hypotheses, we first compiled a list of all publicly traded firms in Thailand from Stock Exchange of Thailand (SET) and Market for Alternative Investment (mai). We then catalogued all foreign subsidiaries (located in Thailand) of publicly traded firms in the stock exchanges of United States (NYSE and Nasdaq), United Kingdom (London Stock Exchange: LSE) and Japan (Tokyo Stock Exchange: TSE, first section). For firms that are listed in several stock exchanges, we determined the origin of these foreign subsidiaries based on the location of the firm's headquarter.

Questionnaire data was collected due to the nature of research and the lack of secondary data. We did a pre-test to check for clarity and validity of questionnaires, as well as to test for the relationships among major variables in the study. The final version is a 5-page questionnaire.

The total population of 1,100 firms was approached for approval from the management to participate in the research. We employed a group of Thai undergraduates (fourth year) to help administer the surveys. These students were carefully instructed for the task. Respondents were asked to retain their own and their firms' anonymity in the belief that they would be more likely to take part in the research and to answer questions more frankly. One questionnaire was sent to each firm during January-March, 2012, along with cover letter and directions on how to answer. The respondents had the option to have the questionnaires sent by fax, email or in person. The respondents could choose if they prefer Thai or English questionnaire. This is to ensure that concepts are appropriate and valid in cultures under investigation and to reduce misunderstandings in responses because some respondents may be more comfortable in one language over another. We translated our questionnaires into Thai using a back-translation to assure comparability and equivalence in the meaning of questionnaire (Brislin, 1970). Non-respondents were mailed a reminder note every week for three times in order to try to increase response rate. However, because the data collection period was during the firms re-opening after the flood incident of Thailand in 2011-2012, this may be a principal justification why response rate is a bit low. We believe firms did not have enough time to partake in the research due to pressing issues caused by the flood.

The results obtained from the questionnaires were compared with those from the pre-test involving business practitioners. The comparison of results revealed no

significant differences with respect to major variables and their relationships in the study.

CHAPTER 2
A resource pool for environmental innovation

This paper reports research on the relationship between sourcing strategy of a firm and its environmental innovation. The data is taken from the Spanish Technological Innovation Panel (PITEC) survey during the period of 2007-2011. The uniqueness of the Spanish innovation structure and the increasing relevance of environmental issues for the Spanish economy make it a proper setting to investigate environmental innovation dynamics. The results from over five thousand firms indicate that large firms are more likely to undertake environmental innovation than small- and medium-sized firms (SMEs). These firms rely equally on all four sources of knowledge – internal, market, institutional and freely-available sources – when deciding to develop environmental innovation. Therefore, the broad horizons with respect to knowledge sources are likely to increase firms' environmental innovation. In addition, we provide the differences in the nature of firm's innovation search depending on firm size. Of all the four sources, a reliance on market sources does not lead small firms to develop environmental innovation. Medium firms that rely on internal, market and freely-available sources are more likely to develop environmental innovation, while it is market and institutional sources for larger firms.

2.1 Introduction

The concern for the environment has brought about increasing pressure on mankind to preserve and maintain natural resources (Bilbao-Osorio et al., 2012; Elkington, 1994). This has led to various developments of environmental laws, policies and programs in recent years such as Clean Air Act, ISO14001, tradable emissions, or United Nations Environment Program (UNEP). It is now becoming increasingly clear that business should play a role in achieving these greening goals (Elkington, 1994; Johnstone, Hascic, & Ostertag, 2008) and since one of the mechanisms for firms to deal with the changing environment is through innovations (Schoonhoven, Eisenhardt, & Lyman, 1990), environmental innovation therefore presents itself as an effective and indispensable solution to respond to this mounting pressure and changing environment (De Marchi, 2012; Johnstone et al., 2008).

The purpose of this paper is to extend traditional innovation literature on search strategy, into environmental innovation context. Though innovation is a risky business, firm's success indeed depends on its ability to innovate consistently (Rosenkopf & Nerkar, 2001). The fact that firm's core knowledge development is inextricably linked to its search strategy that shapes firm's innovation (Katila & Ahuja, 2002), a study on search strategy warrants a detailed study. Greek myth has goddess of wisdom, Athena, bursts fully-grown from Zeus' head, but firms' knowledge does not aborn in one instance like Athena (Leonard-Barton, 1995). No wonder 'learning organizations' are lauded for their ability to generate, source, acquire, and integrate different sources of knowledge (Nonaka & Takeuchi, 1995; Rosenkopf & Nerkar, 2001). We are interested in studying the relationship between knowledge sourcing and firms' environmental innovation. We empirically examine different sources – namely market sources, internal sources – firms employ as inputs into their decisions to develop environmental innovation. We also examine the effect of what we call 'breadth' of knowledge sources on environmental innovation.

Indeed, numerous papers have addressed the relationship between environmental issues and firms, such as how to develop proactive environmental strategy (Aragón-Correa & Sharma, 2003) or benefits from operating in an environmentally-friendly manner (Bansal & Clelland, 2004). However, innovation with respect to environment per se has not yet been analyzed in sufficient depth, principally due to unavailability of

data (Toshi, Hibiki, & Johnstone, 2007). The paper contributes in several important ways.

First, we help shed light on the nature of environmental innovation search, specifically, on where firms seek knowledge from during their search process and the importance of each knowledge source, whether they are small or big firms, new or old, or in the manufacturing or service industries. In this regard, we offer an insight into the evolutionary nature of firms' reliance on different sources of knowledge as they grow from small to big. As yet, few attempts have been made to theoretically and empirically link firms' search strategy with environmental innovation. Basically, empirical analyses on any types of driving forces of environmental innovation whatsoever are still rare (Chang, 2011; Horbach, 2008).

Second, we add to the field by analyzing not just one type of knowledge source, but different types of knowledge sources together. Such study provides the opportunity to not only examine the different search strategies firms employ, but also to assess the degree of openness of firms' search strategies, or as we call 'breadth' in this paper. To our knowledge, rarely are several types of knowledge sources are compared simultaneously.

Third, our data spans forty-three industries. We are not confined to one single sector study or on small samples of particular industries like most previous works in search strategy literature (Laursen & Salter, 2004). Furthermore, the existing literature is largely based on patent analysis, which provides an incomplete perspective on innovation. Patents vary in economic importance across sectors (Laursen & Salter, 2004) and particularly patent data is still not an effective mean to measure environmental innovation (Toshi et al., 2007). In addition, overall patenting activity in Spain, including eco-patenting is low. Spain has one of the lowest ratios of patents per million habitants in Europe according to the European patent office (Sorli & Zambrano, 2011). As we are not using patent data, we surmount this limitation and provide intelligence into environmental innovation issue from another perspective.

Lastly, previous studies mainly provide a small sample analysis of listed firms or of specific industry, particularly the environmental goods and services industry (Kemp & Pearson, 2007). Our study, on the contrary, is based on a large scale dataset of over five thousand observations, ranging from local micro-firms to very large multinational companies. In doing so, we could expand the literature into other types of firms and other industries. Moreover, we use Spanish Technological Innovation Panel (PITEC)

survey, which is based on the Community Innovation Survey (CIS). PITEC is not only a valid tool in studying innovation, but it also offers direct comparisons of this work with other numerous works based on CIS data.

Spain is considered a moderate innovator (Hollanders & Es-Sadki, 2013) with 1.45% gross domestic expenditure on R&D in 2010 versus 2% of the EU average (Eurostat, 2013), yet Spain is very advanced in terms of environmental innovation, being among one of the top in the world (Barranco, 2013). In this manner, Spain provides an interesting context to study environmental innovation.

Our results show that firms rely equally on the four sources of knowledge – internal, market, institutional and freely-available sources. Thus, the broad knowledge horizons are likely to increase firms' environmental innovation. In addition, the results also indicate that firms of different sizes rely on different sources. Small firms rely on internal, institutional and freely-available sources equally, while market and institutional sources are relevant for large firms in driving environmental innovation.

To date, the terms eco-innovation, environmental innovation and green innovation have been used synonymously (Tietze, Schiederig, & Herstatt, 2011). In this paper, we adopt the definition below.

> "Eco-innovation is the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization… and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use)…" (Kemp & Pearson, 2007: 7).

The remainder of the paper is organized into four parts. Part two focuses on the literature explaining the relationship between knowledge sources and environmental innovation. In Part three, we present the data, and in Part four, we analyze the results. Part five discusses and part six concludes.

2.2 Literature review and hypotheses

2.2.1 Where do firms get producing inputs to make decisions to develop green innovation?

According to a prevalent model of technological change by Griliches (1979), innovative output is the product of knowledge generating inputs. A successful innovation depends on how successful firms are at identification of, deliberate search for, reaching out to, managing and implementing these promising sources (Cohen & Levinthal, 1990; von Hippel, 1988).

Internal knowledge offers a number of advantages over the reliance on outside research and development, particularly when aspects of relevant knowledge needed to develop innovation is tacit and somewhat idiosyncratic (Nelson, 1986). With an inward focus, firms focus on similar technology previously developed and become experts in their current technological domains (Dosi, 1988). On the other hand, firms' ability to detect and exploit outside knowledge proves to be critical to the innovation processes (Leiponen & Helfat, 2010). They gain ideas for innovating from a wide variety of different sources (Cohen & Levinthal, 1990; Laursen & Salter, 2004), particularly from market sources such as from customers and users (von Hippel, 2009), suppliers (Leiponen, 2002), and competitors (Cassiman and Veugelers, 2006).

Empirical evidence shows that knowledge from and cooperation with suppliers are important for the development of environmental innovation, especially to ensure eco-friendly features of the inputs (De Marchi, 2012). Exchanges of information with customers also prove to be a key to help firms reach their environmental targets (Theyel, 2006). Although knowledge on environmental innovation is still rather concentrated in the public sector (Horbach, Oltra & Belin, 2013), the ability of firms to draw knowledge directly or indirectly from these public institutions such as universities, government-funded research centers may be difficult. Resource limitations might constrain firms' reach to these institutions during their search process, especially for small firms. It may also be that it is not that simple and easy to establish appropriate network of contracts with these public sectors for their scientific and technological expertise. Knowledge transfer from freely-available sources through formal events such as trade fairs or exhibitions may be more difficult than through informal social activities such as going out to lunch or drinks. According to knowledge-based theory of the firm,

informal interpersonal networks play critical role in knowledge transfer process. They ease knowledge transfer, helping to motivate individuals to invest energy, time and effort in sharing knowledge. Particularly an individual is more likely to exert greater effort to transfer knowledge to a close personal contact (Reagans & McEvily, 2003). We propose the following hypothesis:

> *Hypothesis 1: Firms that draw knowledge more from internal and market sources are more likely to decide to introduce environmental innovation than firms that draw knowledge from institutional or freely-available sources.*

2.2.2 And the relation with size

Firms of different sizes behave differently in terms of innovation and face different innovation-related circumstances, for instance, access to funding differs by size (Busom, Martinez-Ros & Corchuelo, 2011), inducing them to employ different search strategies. They exhibit changes in the way they organize, reorganize, outsource and/or shift the origin of their knowledge creation (Laursen & Salter, 2004).

Small firms, particularly small start-ups, are often viewed as key vehicles transferring university research into commercial innovation (Acs, Audretsch and Feldman, 1994; Jaffe, 1989). Moreover, with entrepreneurial spirits from small start-ups, entrepreneurs tend to possess self-efficacy trait (Bandura, 1986). They believe in their own ability to complete tasks. This might be what drives smaller firms to rely on themselves more. On the other hand, it might also be that other firms or institutions are not interested in working with small firms due to the liability of smallness (Bruderl & Schussler, 1990; Freeman, Carroll & Hannan, 1983). It can be difficult for most small firms to establish appropriate network of contracts with external actors for scientific and technological expertise. After all, innovation is essentially a learning process, where it often involves more than two actors (Freel, 2003). These can be the reasons obliging small firms to look to their internally-generated knowledge as the first option.

For medium firms, we expect them to draw on internal knowledge. As the size becomes bigger, these medium-sized firms start to be able to afford internal R&D, conduct more R&D and be involved in more R&D projects (Cohen et al., 2002). Internal R&D provides firms with the capability to both develop new products and processes as well as to absorb knowledge from outside the firm (Cohen & Levinthal,

1990). Even under circumstances where collaborative effort with external actors is required, it is thought essential that firms develop internal competencies first in order to be able to facilitate the effective recognition, appraisal, negotiation and assimilation of external expertise (Dosi, 1988).

Furthermore, we also expect small and medium firms (SMEs) to draw rather equally from freely-available sources. Cohen et al. (2002) suggest that the most important channels for firms to access public research, or as we call it institutional source in this paper, are through publications and conferences rather than licenses or cooperative ventures. These firms are confronted with limited resources and often are faced with internal shortages of information (Lu & Beamish, 2001). The standard practice to move knowledge across firm boundaries often involves contractual agreements (Rosenkopf & Nerkar, 2001) that can be costly for these SMEs. Drawing from freely-available sources presents itself as an appropriate strategy because it does not incur or incur little costs.

We postulate the following hypotheses:

> *Hypothesis 2: Small firms draw knowledge from internal, institutional and freely-available sources when deciding to introduce environmental innovation.*
>
> *Hypothesis 3: Medium firms draw knowledge from internal and freely-available sources when deciding to introduce environmental innovation.*

Larger firms are the ones who are more responsive to the changes in their industry R&D than smaller firms (Acs et al., 1994). Because larger firms often have a wider spread of knowledge base, they are better apt at absorbing and exploiting complementarities from external sourcing (Laursen & Salter, 2004; Veugelers & Cassiman, 1999). Many times, larger firms simply buy their smaller-sized competitors in order to obtain their knowledge (Arora & Gambardella, 1990; Veugelers & Cassiman, 1999). Besides, technology outsourcing creates considerable costs, ex ante in terms of search and ex post in terms of execution and enforcement (Veugelers & Cassiman, 1999). It will not be surprising if these firms form strategic alliances or joint ventures with suppliers and competitors. Firms can also work closely with customers, or even hire consulting firms, notably the ones who are specialized in environmental

compliance or sustainability. We expect larger firms to be the ones who are able to afford this option more than their smaller counterparts.

Concerning drawing from institutional sources, prior argument is that larger firms can dedicate greater time and resources in building the links with universities than small firms who may operate in a more resource-constrained context. Larger firms may also employ more staff with professional background, who may be able to draw from their relationships with the universities to support the work of the firms. In this regard, larger firms are more likely to have the capability to exploit this external knowledge and to manage interactions with universities. As most research in this field is still concentrated in the public sector (Horbach et al., 2013), it is only natural that firms look to these institutions for ideas.

Consistent with previous research, the hypothesis can be stated as:

> *Hypothesis 4: Large firms draw knowledge from market and institutional sources when deciding to introduce environmental innovation.*

2.2.3 And the relation with the intensity of sources of knowledge used

Since Solow's work in 1957, researchers and practitioners alike have been associating strong internal knowledge with innovativeness (Gassmann, 2006). However, prior research also argues that myopic behavior of narrow search from only within firms leads to potential developments of 'competency traps' (Levitt & March, 1988) and/or 'core rigidities' (Leonard-Barton, 1995). Gains associated with internal technology development alone are not sustainable unless firms integrate outside knowledge (Rosenkopf & Nerker, 2001). As a consequence, a wider and more diverse search create more opportunities to access and integrate knowledge sets (Katila, 2002; Nelson & Winter, 1982). Because innovation often results from knowledge fusion or novel recombination from several sources (Kogut & Zander, 1992), pursuing breadth of knowledge helps to increase the odds of innovation success.

For environmental innovation that is riskier, requires greater financial commitment than traditional innovations (Berrone, Fosfuri, Gelabert & Gomez-Mejia, 2013) and is still relatively new and unknown (Horbach et al., 2013), similar logic could be applied and may be needed even more so than the case of traditional innovations. Our key assumption is that a diverse search could help ready firms for environmental

innovations. Breadth of knowledge would warrant firms with a vast supply of knowledge inputs to develop innovation with eco-friendly features. Particularly in a context where there exists a high uncertainty about which knowledge domain would provide potentially useful information, broad and simultaneous search could help firms hedge against uncertainties, ensuring that at least one of the sources would lead to environmental innovation. Knowledge diversity provides not only a more robust basis for learning, but also interactions across different knowledge sources would help augment firms' ability in making novel linkages and associations beyond the reliance on a single source alone (Cohen & Levinthal, 1990). In order to examine this question, we develop a proxy variable for 'breadth' of a firms' innovation search strategy. The variable is based on the number of different sources of knowledge each firm draws on in its innovative activities. The foregoing arguments suggest the following hypothesis:

> *Hypothesis 5: The higher the level of breadth of knowledge sources the individual firm draws from, the more likely it will develop environmental innovation.*

2.3 Methodology

Data, Empirical Setting and Methodology

The empirical setting in this study is Spanish firms. The data is taken from Spanish Technological Innovation Panel (PITEC) survey[1]. It is carried out yearly by the Spanish National Statistics Institute (INE) in collaboration with the Spanish Science and Technology Foundation (FECYT) and the Foundation for Technological Innovation (COTEC).

The choice for this dataset is multifold. First, PITEC is one of the very few large-scale surveys that provides usable data on environmental innovation. Second, PITEC is based on the Community Innovation Survey (CIS) framework, which is a valid tool in studying innovation and is one of the most used datasets for studying innovation (Laursen & Salter, 2004, 2006). This enables direct comparisons of this work with previous empirical literature as well as future research using similar datasets. Finally, the uniqueness of the Spanish innovation structure and the increasing relevance

[1] The dataset, the questionnaire and the description of each variable is available free of charge at the website http://icono.fecyt.es/PITEC/Paginas/por_que.aspx

of environmental issues for the Spanish economy (De Marchi, 2012) make it a proper setting to investigate environmental innovation dynamics. Spain is considered as a moderate innovator (Hollanders & Es-Sadki, 2013). The gross domestic expenditure on R&D was 1.45% in 2010 versus 2% of the EU average (Eurostat, 2013). In terms of the overall innovation performance based on the Innovation Union Scoreboard 2013 by the European Commission, Spain also under-performed with respect to other EU 27 countries, scoring 0.41 versus 0.54 (Hollanders & Es-Sadki, 2013). However, Spain is aiming towards more environmental innovation to help boost its economic growth. Spanish green patent applications have grown the most, among others of China, India, Italy and Japan, between 2000 and 2009 (Barranco, 2013).

Given the lack of data availability at a project level, we study environmental innovation at a firm level. Though PITEC has been administered since 2003, the changing nature of the sample and of PITEC questionnaire poses challenges for inter-temporal analyses. In addition, data on environmental innovation is available only in a block of period. We therefore are restricted to cross-sectional methodology.

At present, PITEC sample contains about 13,000 firms and comprises four sub-samples. The first sub-sample is composed of firms with 200 employees or more while the second represents firms with internal R&D expenditures. In 2004, two more sub-samples were included. They are firms with less than 200 employees who report external but no internal R&D and the last sub-sample is firms with no innovation expenditures. The degree of representativeness of the population depends on the size of the company. While it is representative for the firms with more than 200 employees, the representativeness of firms with less than 200 employees are biased towards firms having internal and/or external R&D. About 74% of firms in the sample claim to innovate. They are identified by their answer to the question regarding whether or not they have introduced innovation in the previous two years.

We combine PITEC survey for the period of 2011 with PITEC survey for the period of 2009. The former contains our dependent variable while the latter contains our explanatory and control variables. Given the nature of the innovation process and its complexity, it is quite unlikely that the explanatory variables immediately generate environmental innovation. For this reason, we use probit model to regress environmental innovation in year 2011 (which is referred to environmental innovation for the period of 2009-2011) on sources of knowledge and breadth of knowledge that firms drew on during the period of 2007-2009. We use a two-year window as the data

on environmental innovation and knowledge sources are available only in a block of period of two years. The use of lag helps to alleviate simultaneity issue as well as to reduce the potential problem of common method variance (Podsakoff & Organ, 1986) and reverse causality (Wooldridge, 2013). Nevertheless, we check for common method variance using Harman's one-factor test. We perform factor analysis on all variables using unrotated factor analysis and principal component analysis with and without varimax rotation. The results suggest no potential problem of common method variance. No single factor emerges and no factor accounts for a majority of variance (with 36% for the first factor). Our effective sample consists of 5,321 firms from forty-three industries.

Dependent variable

To measure environmental innovation, we follow the approach of De Marchi (2012) in using self-report data on the objectives of the innovation introduced. In many previous studies, environmental innovation has been commonly measured using questionnaire surveys (Anton, Deltas & Khanna, 2004; Christmann, 2000). Kemp and Pearson (2007) suggest using this method to measure environmental innovation, rather than using environmental investments (input) or environmental patents (output) that have been extensively employed (Nameroff, Garant, & Albert, 2004). Using environmental R&D presents problems as this proxy could lead to over- or under-estimation of innovation (De Marchi, 2012). Further, allocation of expenditures for specific objectives is determined by managers; however, drawing the exact boundaries between different objectives is by no means straightforward (Grupp, 1998). The use of green patents also raises methodological issues (Toshi et al., 2007). There is no widely accepted agreement in the literature yet as to what constitutes environmental technology and the patent classification system does not provide specific categories for environmental patents. The identification of green patents is based solely on researchers' judgments and understandings (Kemp & Pearson, 2007). In addition, patenting activity in Spain, including eco-patenting is low. Spain has one of the lowest ratios of patents per million habitants in Europe according to the European patent office (Sorli & Zambrano, 2011). Consequently, one may argue that the use of objective is not inferior to the use of environmental R&D or environmental patents.

To construct our dependent variable, we utilize questions of PITEC survey that ask about the importance of the following objectives for their innovations: (1) using less material; (2) using less energy; (3) lower impact on the environment; and (4) complying to the requirements on environment. The survey asks each firm to evaluate the importance of each objective based on a Likert scale of 1 to 4, with 4 as null and 1 as very important. We first assign binary values for each objective. A response of 1 (very important) or 2 (important) receive a binary value of 1, where responses of 3 (some importance) and 4 (null) receive a binary value of 0. We then aggregate these answers and rescale the total score into 0 and 1, with firms having 0s across all four objectives as 0, and 1 otherwise. About 78% of firms in the sample are environmental innovators. Binary values help to reduce the problem where the ordinal nature of Likert scale cannot be interpreted as interval scale (Leiponen & Helfat, 2010). The use of a dummy as a dependent variable also allows comparing the emerging evidence with existing literature (De Marchi, 2012, Horbach, 2008).

Unfortunately, PITEC is not specifically designed to investigate green innovation per se. This variable thus could be criticized. To mitigate the potential problem, we employ different specifications for our dependent variable, testing the robustness of the model.

Explanatory variables

The key explanatory variables in our study represent different sources of knowledge and breadth of knowledge sources firms utilize in their innovation activities. PITEC asks respondents to identify the importance of each of the sources of information used in innovation activities. The survey lists altogether eleven different sources of information for innovation, listed in Table 1.

TABLE 1
Knowledge Sources

	Sources	Mean	s.d.
Internal	Own firm (within the firm and/or group)	0.86	0.35
Market	Suppliers	0.59	0.49
	Customers	0.60	0.49
	Competitors	0.42	0.49
	Consulting firms, private research institutes	0.36	0.48
Institutions	Universities or other higher educational centers	0.29	0.45
	Public research institutes	0.21	0.41
	Technology centers	0.30	0.46
Freely-available	Conferences, trade fairs, exhibitions	0.43	0.50
	Scientific journals and trade/technical publications	0.38	0.48
	Professional associations	0.28	0.45

To construct variables for different types of knowledge sources, we adopt the approach used in Leiponen and Helfat (2010)'s paper. We assign a response of 1 (very important) or 2 (important) to a binary value of 1, and a response of 3 (some importance) and 4 (null) to a binary value of 0. To simplify the model and to account for potential overlap among knowledge sources, we group knowledge sources into broader categories. The first type of knowledge source remains as it is and it represents an internal source. The next four are grouped into market sources, the next three into institutional sources, and the three remaining sources into a fourth category of freely-available sources. These represent external knowledge sources. We follow Veugelers and Cassiman (1999)'s approach when aggregating different sources together: summing binary scores on related variables and rescale the total score to a 0 and 1.

To construct a variable indicating breadth of knowledge sources, we follow the approach other researchers (Laursen & Salter, 2006; Leiponen & Helfat, 2010) have used with CIS data. We sum binary values of the eleven sources together. This variable has a maximum value of eleven. The mean value is 4.71.

Control variables

Firm type: listed, private or institutes. Firms that are listed face more pressure to be environmentally friendly due to transparency and visibility of being listed; nonetheless, being listed facilitates easier access to capital to finance environmental innovation (Toshi et al., 2007). Consequently, we include dummies of private firms, listed firms, or institutes as controls. For private firms, we control for (1) private firms with no foreign capital, (2) private firms with foreign capital less than 10%, (3) private

firms with foreign capital between 10-50%, and (4) private firms with foreign capital more than 50%.

Size. Size has been found to affect environmental innovation propensity. Smaller firms are found to have difficulties in finding investments needed to switch to greener technologies and in dealing with complexities of environmental innovation (Toshi et al., 2007). Firm size is included through three dummies: small (1-50 employees), medium (51-200 employees) and large (more than 200 employees).

Innovation effort. Cassiman and Veugelers (2006) find that higher innovation expenditure, controlling for size, increases firms' likelihood to engage in innovation activities. The data on the R&D expenditures is simulated so using R&D intensity would be more appropriate. We extend from traditional innovation literature and use the same approach of using the natural log of total innovation expenditures divided by total sales to control for R&D intensity, or firms' previous innovation effort from 2007-2009, for environmental innovation context.

Innovation output. Serial innovators are more likely to introduce green innovation (De Marchi, 2012, Horbach, 2008). The variable 'product innovation' gets the value of 1 if firm reports to have introduced product innovation during 2007-2009.

Funding. We include dummies reflecting public support to innovate; valuing 1 if firms have received public support in the form of subsidies for innovation purposes during the period of 2007-2009. Policymakers have been using a market-based instrument such as subsidies to stimulate development and diffusion of environmental technologies (Rennings, 2000). We control for both local funding from the Spanish government and European Union-level funding.

Industry dummies. It is necessary to control for industry differences. Level of R&D for environmentally-related innovation differs by industry type (Toshi et al., 2007). Demands and technological opportunities along with consumers' awareness and policy restrictions concerning environments also vary across sectors (De Marchi, 2012; Toshi et al., 2007). We hence include forty-three industry dummies in our model.

We would like to include a control of firm's environmental performance, as suggested by previous literature (Lázaro, Dorronsoro, Casas, Rodríguez, & Sedano, 2008). This control variable could be a dummy of whether or not a firm is ISO14001 certified, EMAS registered, has environmental reports, or the like. Unfortunately, PITEC data is anonymized. We could not complement the dataset with externally-obtained information.

Table 2 presents the definitions of our variables and some descriptive statistics.

TABLE 2
Variable Definitions

Variables	Description	Mean	s.d
Environmental innovation	Environmental innovation	0.65	0.48
	- Less material	0.39	0.49
	- Less energy	0.40	0.49
	- Lower impact on the environment	0.49	0.50
	- Compliance to environmental, health and security requirements	0.50	0.50
Internal	Importance of internal information as sources for the innovation process.	0.86	0.35
Market	Importance of markets as sources for the innovation process.	0.84	0.40
Institutions	Importance of institutions as sources for the innovation process.	0.42	0.49
Free	Importance of other sources as sources for the innovation process.	0.55	0.50
Breadth	Breadth of sources of knowledge (0-11)	4.72	2.85
Listed	Listed firm	0.02	0.15
Private (local)	Private firms with no foreign capital	0.79	0.41
Private (<10%)	Private firms with foreign capital less than 10%	0.02	0.13
Private (10-50%)	Private firms with foreign capital between 10-50%,	0.02	0.15
Private (>50%)	Private firms with foreign capital more than 50%	0.13	0.33
Institutes	Institutes	0.02	0.14
Small	Small firm of 1-50 employees	0.47	0.50
Medium	Medium firm of 51-200 employees	0.28	0.45
Large	Large firm of more than 200 employees	0.25	0.43
R&D intensity	Natural log of Total innovation expenditure/total sales	-3.53	1.94
Product Innovation	The firm has introduced product innovation	0.74	0.44
Local funding	Receive Spanish public funding (subsidies)	0.45	0.50
EU funding	Receive public funding (subsidies) from the EU	0.07	0.25
Parent	Parent company	0.23	0.42
Subsidiary	Subsidiary of another firm	0.67	0.47
JV	Joint venture	0.03	0.16
Partnership	Partnership	0.08	0.27
Industry	43 industries as according to CNAE 2009		

2.4 Results

The correlations between different sources of knowledge and environmental innovation are positive and significant. The correlation between breadth of knowledge sources and environmental innovation is positive and significant ($r = 0.22$, $p < .05$). All the different types of sources of knowledge are also positively correlated to each other. Concerning control variables, only research institutes are positively correlated with environmental innovation ($r = 0.05$, $p < .05$), while negatively correlated for listed firms ($r = -0.03$, $p < .05$). Small firms are negatively correlated with environmental innovation ($r = -0.09$, $p < .05$) while medium and large firms are negatively correlated ($r = 0.05$, $p < .05$; $r = 0.07$, $p < .05$). It is interesting to note that R&D intensity (1) does not

correlate with environmental innovation or listed firms; (2) correlates positively with research institutes (r = 0.26, p < .05) and small firms (r = 0.41, p < .05); and (3) negatively correlates with large firms (r = -0.37, p < .05). Both Spanish and EU subsidies correlate positively with environmental innovation (r = 0.12, p < .05; r = 0.04, p < .05, respectively). Firms that introduced innovation in the previous two years are positively correlated with environmental innovation (r = 0.15, p < .05). See Appendix A for further detail. The correlations indicate low probability of multicollinearity problem. Nonetheless, we further verify using Collin command in Stata. The variance inflation factors (VIFs) are in the range of 1.07-8.16 with the mean of 2.13, indicating no evidence of multicollinearity.

Table 4 reports results of hypotheses 1-5, testing the relationships between four different sources of knowledge and environmental innovation. Column (I) reports the coefficients and marginal effects of the full model, testing hypothesis 1. The result testing hypothesis 5 is reported in Column (II), investigating the impact of breadth of knowledge sources on environmental innovation. The results of hypotheses 2-4 are reported in Column (III), (IV) and (V), testing the relationships run on different sub-samples based on firm size: small (1-51 employees), medium (51-200 employees) and large (more than 200 employees), respectively.

TABLE 4
Regression Results for Knowledge Sources

	(I) Full		(II) Breadth		(III) Small	(IV) Medium	(V) Large
	β	ME	β	ME	ME	ME	ME
Internal	0.2489**	0.0880**			0.0945**	0.0962*	0.0742
Market	0.2522**	0.0892**			0.0524	0.0829*	0.1521**
Institutions	0.1635**	0.0578**			0.0829**	0.0175	0.0682*
Free	0.1997**	0.0706**			0.0868**	0.0759**	0.0409
Breadth			0.0820**	0.0290**			
Constant	-0.5815**		-0.3649**				
Controls:							
Private (local)	0.2020	0.0714	0.2205†	0.0778†	0.1041	0.1897†	0.0504
Private (<10%)	0.2404	0.0850	0.2180	0.0770	0.1097	0.3900*	-0.0588
Private (10-50%)	0.2260	0.0799	0.2352	0.0831	0.2240†	0.1232	-0.0091
Private (>50%)	0.2937*	0.1049*	0.3143*	0.1110*	0.1319	0.2187*	0.0535
Institutes	0.5228*	0.1849*	0.4992*	0.1763*	0.2497†	0.2292	0.2672†
Medium	0.1495**	0.0528**	0.1456**	0.0514**			
Large	0.3745**	0.1324**	0.3714**	0.1311**			
R&D intensity	0.0493**	0.0175**	0.0499**	0.0176**	0.0090	0.0200*	0.0192*
Product innovation	0.2779**	0.0983**	0.2842**	0.1004**	0.0960**	0.0977**	0.0758*
Local funding	0.1157**	0.0409**	0.1097**	0.0388**	0.0321	0.0317	0.0606*
EU funding	0.0029	0.0010	-0.0148	-0.0052	-0.0372	0.0628	0.0583
Industries	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Predicted probabilities		71.11%		70.72%	68.04%	74.30%	76.17%
N	5321	5321	5321	5321	2478	1510	1305
Probit model:							
Log likelihood	-3005.44		-3005.09		-1495.32	-818.11	-636.28
LR Chi2 (50)	725.33**		726.04**		293.89**	198.32**	274.30**
Pseudo R^2	10.77%		10.78%		8.95%	10.81%	17.73%

*$p < .05$, **$p < .01$
Note: the β column reports coefficients, while the ME column contains marginal effects of the coefficients calculated at means.

The results from Column (I) show that the coefficients and marginal effects of all four sources are positive and significant. However, the t-test of difference shows that these coefficients are not significantly different from others, therefore, not supporting hypothesis 1. The signs of most control coefficients are as expected. Large and medium firms are more likely to develop environmental innovation. Firms that have previously developed innovation display a stronger likelihood to introduce environmental innovation. Local funding, rather than EU funding, even in the form of subsidies, still are likely to encourage firms to develop environmental innovation. Surprisingly, there are only few manufacturing industries that are likely to develop environmental

innovation. They are food and drinks, chemicals, plastics. Service industries such as transport, information and communication services and other auxiliary services, on the contrary, are unlikely to develop environmental innovation. The model correctly predicts 71.11%.

The results from Column (II) support hypothesis 5. The higher the level of breadth of knowledge sources employed by individual firm, the more likely it will develop environmental innovation, compared to other firms with lower level of breadth. The result for hypothesis 5 merely highlights the reason why hypothesis 1 is not supported.

Concerning the different sub-samples, Column (III) shows that the decisions of small firms to develop environmental innovation depends on internal knowledge and equally on institutional and freely-available sources. Our findings support hypothesis 2. The results from Column (IV) do not support hypothesis 3. Large firms relying on market and institutional sources are more likely to develop environmental innovation, confirming hypothesis 4.

We perform additional robustness checks. Another specification of the dependent variable is again used. Instead of a dummy, we perform a factor analysis on the four objectives. We then run OLS and GLM regression on this factor. We also perform Heckman in case of potential selection problem as the sample in PITEC for small firms is biased towards firms with internal and/or external R&D expenditures. Furthermore, we run regressions with different specifications for our proxies for explanatory and some control variables. The results do not change.

2.5 Discussions

Our results indicate that firms with broader horizons with respect to knowledge sources are more likely to introduce environmental innovation. An interesting finding is how firms rely equally on the different sources for environmental innovation. In this manner, it is no surprise that the coefficient of breadth of knowledge type is positive and significant. This evidence of the co-occurrence of internal and external knowledge sourcing activity is consistent with previous works on the sourcing strategy for traditional innovation (Leiponen & Helfat 2010; Nelson & Winter, 1982). Firms do indeed tap into external knowledge sources in addition to internal knowledge (Arora & Gambardella, 1990). Even the largest innovation-active firms today rely on both internal

sourcing and external knowledge when developing innovations (Cassiman & Veugelers, 2006; Rigby & Zook, 2002). Because innovation often draws on many sources of ideas, results from knowledge recombination (Kogut & Zander, 1992; Leiponen & Helfat, 2010) and due to information asymmetry (Venkataraman, 2002), firms with access to a larger variety of sources of knowledge are in a better position to identify and develop environmental innovation opportunities. Despite discussions concerning how knowledge is tacit, the mobility of knowledge has increased tremendously over the years (Gassmann, 2006). A chance of success is indeed maximized when firms search broadly (Jewkes, Sawers, & Stillerman, 1958; Leiponen & Helfat, 2010).

The fact that small firms draw from internal source, despite its small size and resource constraints, is not strange. Internalized corporate search allows firms the ability to exploit the future cumulativeness and the complexity of technological knowledge as well as helping to reduce the uncertainty of innovative search without eliminating the chance to innovate (Dosi, 1988). After all, in most industries, the greater part of the innovation effort is made by the firms themselves (Gassmann, 2006; Solow, 1957). Small firms also rely on institutional and freely-available sources as we postulate. Our findings are consistent with Jaffe (1989)'s and Acs et al. (1994)'s works. They show that spillovers from university research laboratories are more important in producing innovative activity in small firms.

Prior research shows that increasing firm size is positively associated with external linkages (Freel, 2003). Particularly innovative activities of larger firms are more responsive to industry innovations as compared to smaller firms (Acs et al., 1994). In line with previous research, our results show that market and institutional sources drive the probability to develop environmental innovation in large firms. Our findings concerning the importance of large firm size in the use of university knowledge corresponds to those of Cohen et al., (2002) and Laursen and Salter (2004). This can be because larger firms are more likely to both make and buy technology, as suggested by the literature. Larger firms can simply acquire new environmentally-related technologies both through the embodied format of hiring away competitors' top personnel or working with consultants, or through the disembodied format of directly acquiring other firms, buying blueprints or R&D outsourcing to other firms (Veugelers & Cassiman, 1999). Property rights theory (Grossman & Hart, 1986) and transaction costs economics (Pisano, 1990; Williamson, 1985) explain that such R&D outsourcing helps firms to tap into existing, often specialized, knowledge and aids firms in time

gains, lower innovation costs, and allowing for R&D economies of scale to be more efficiently exploited (Veugelers & Cassiman, 1999).

Likewise, instead of contracts with external actors that can be expensive and may cause opportunistic behavior (Veugelers & Cassiman, 1999), another possible option is cooperative agreements (Oxley, 1997) such as alliances. In particular, environmental innovation is riskier, requires more resources than traditional innovations (Berrone et al., 2013) and is still largely unknown (Horbach et al., 2013). This option of cooperative agreement can present itself as appropriate. It allows firms to share costs and risks. It allows firms to have access to external technologies that would otherwise be impossible to get a hand on. It also allows firms to have the opportunity to exploit the synergy from knowledge complementarity among partners (Arora & Gambardella, 1990; Veugelers & Cassiman, 1999). To form or enter into such a network of alliance, it is usually based on a careful selection of partners where reputation does matter (Gulati, 1995). Additionally, hold-up problem can occur. The typical complex and uncertain nature of R&D projects can also exacerbate the problem (Veugelers & Cassiman, 1999). Thus, this could be a difficult option for smaller firms to pursue or there can be too little incentives or too high costs for smaller firms to deal with, again largely due to liability of smallness and newness (Bruderl & Schussler, 1990; Freeman et al., 1983; Stinchcombe, 1965).

Care should be taken into account when interpreting the reliance of SMEs on internal sourcing to spur environmental innovation. We cannot distinguish from our dataset if these environmental innovations are end-of-the-pipe type or clean technologies. End-of-the-pipe technologies involve implementing add-on measures that do not require complex technologies, while cleaner technologies are seen as involving more advanced and complex technologies (Frondel et al., 2007). If these green technologies in these small firms are more end-of-the-pipe type, the fact that SMEs conduct internalized corporate search, while larger firms do not, make sense. To develop very advanced clean technologies, a reliance on other partners in order to help reduce risks does not seem to be a strange choice.

Consistent with the work by Toshi et al. (2007), our study also reveals that larger firms are more likely to develop green innovations than small- and medium-sized firms. Smaller firms can have more difficulties in finding investments needed to switch to greener technologies and in dealing with complexities of environmental innovation. While previous research shows that smaller firms do recognize potential gains from

green innovation, the lack of financial resources and time can constrain their ability to develop environmental innovation. For instance, the work by Worthington and Patton (2005) shows that firms with fewer than 25 employees are less likely to be able to commit resources to environmental improvements. On top of that, larger firms, often publicly-held firms, are more subjected to limelight and are often more scrutinized by the public about their actions, particularly concerning social and environmental issues (McWilliams and Siegel, 2001; Waddock and Graves, 1997). The incentives for them to develop environmental innovation can also be high due to this reason.

However, careful interpretations about size are needed as we could not distinguish if these firms engage in environmental innovation for compliance purpose, operation-driven, or from a strategic stance where they see green innovation as a business opportunity to be exploited. Indeed larger firms often show that they are sincere about their environmental concerns, but they usually respond to these pressures through incremental process innovation by adopting environmental communication or management systems (Hockerts & Wustenhagen, 2010). They can be less ambitious in developing environmental innovation than smaller firms because they are already well-established and their sales have not been affected by the whole greening concept. Moreover, they are anchored by their existing assets that reflect past investments (Hockerts & Wustenhagen, 2010). Thus, though larger firms are more likely to introduce green innovation, they can just be doing simply compliance-driven green innovation type.

PITEC data is useful yet it has its limitations. Besides that the sample is biased, as most firms in the dataset are innovators, PITEC is also not built specifically to assess environmental innovation. It limits our approach to measuring environmental innovation from innovation objectives with environmental concerns. We cannot tell the actual outputs and/or economic values from innovation objectives. Our measure also does not allow us to distinguish between firms that introduced end-of-the pipe technology from others whose entire innovative effort is devoted toward the reduction of environmental impact. In general, the main challenge we face is scarce information. Large-scale survey like CIS has attempted to ease the problem by including a section on innovations with environmental benefits in its 2008 questionnaire. However, the section was dropped from its later questionnaires. Also, PITEC data for some variables are provided in blocks of period rather than yearly, limiting us to use cross-sectional methodology.

This study is a preliminary examination on the topic. It presents us with numerous possibilities for future research. First, a great contribution that future research should attempt is to use panel data.

Second, the use of other measures of environmental innovation would help to improve this analysis. An alternative input measure can be environmental innovation expenditures. Another option can be the use of innovation effort factors combined with eco-efficiency performance parameters (Lázaro et al., 2008). The use of a different output measure, besides environmental patent, such as the number of new environmental products or processes will also offer interesting insights (Kemp & Pearson, 2007).

Third, knowledge sourcing for environmental innovation has received the least attention in the environmental innovation surveys so far (Arundel & Kemp, 2009). A valuable avenue for future research could be to break down the relationship studied here into the different typologies of environmental innovation that exist or to study the link between knowledge sourcing and *valuable* environmental innovation with strong environmental and/or economic impact. Researchers could also extend the field by analyzing the issue focusing on the recipients of the spillovers rather than just upon the source. Or researchers could combine with the data on perhaps licensing or managerial choice in shaping firms' propensity to draw from certain sources (Laursen & Salter, 2004). Beyond a diverse knowledge structure, a study of the sort of knowledge that firms possess to help enhance their absorptive capacity to introduce environmental innovation would also be interesting. Critical knowledge does not mean only technical knowledge, but it also includes awareness of where useful complementary expertise resides, be it within or outside firms (Cohen & Levinthal, 1990).

Fourth, theoretical and empirical analyses on determinants of environmental innovations are still rare (Horbach, 2008). A study of other determinants such as public support for environmental innovation (i.e., market-based incentives such as public financing or subsidies specifically for environmental innovations) would be fruitful. In essence, a study on any determinants of environmental innovation would help to advance the field and to help us see whether or not general innovation theories can be applied to environmental innovation contexts.

Lastly, we hope to strengthen our results by comparing our Spanish case against those of other countries that have participated in the CIS survey, as PITEC uses the same questionnaire format as CIS.

2.6 Conclusion

Existing literature has extensively addressed environmental issues and firms but innovation with respect to environment per se has not yet been analyzed in sufficient depth. A lot of understanding about environmental innovation is still needed. This paper reports research on the relationship between sourcing strategy of a firm and its environmental innovation. The data is taken from the Spanish Technological Innovation Panel (PITEC) survey during the period of 2007-2011. Our empirical results suggest that firms that rely on greater breadth of knowledge sources are more likely to introduce environmental innovation. This is no surprise in our context of environmental innovation as the extent of breadth of sources is known to be associated with new approaches towards innovation (Leiponen & Helfat, 2010). The novelty of our study is that, to our knowledge, this is the first statistical study at the firm level that assesses the different types of knowledge sources together along with breadth of knowledge sources. Existing empirical studies have yet to provide hard evidence on the use of knowledge sources in relationship with environmental innovation. This study hopes to provide new insights into how firms can deal with environmental innovation in this modern economy where there is a heightened demand for firms to be environmentally-friendly.

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2.8 Appendix A: Correlation coefficients

Appendix A
Correlation Coefficients

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Environmental innovation	1															
2. Internal	0.15*	1														
3. Market	0.16*	0.35*	1													
4. Institutions	0.15*	0.16*	0.21*	1												
5. Free	0.16*	0.22*	0.33*	0.30*	1											
6. Breadth	0.22*	0.41*	0.54*	0.62*	0.70*	1										
7. Listed	-0.03*	-0.03*	-0.03*	0.04*	-0.00	0.01	1									
8. Private	-0.01	0.00	-0.01	-0.12*	-0.06*	-0.12*	-0.72*	1								
9. Institutions	0.05*	0.03*	0.04*	0.13*	0.09*	0.16*	-0.02	-0.68*	1							
10. Small	-0.09*	-0.06*	-0.03*	-0.02	0.01	-0.04*	-0.08*	0.04*	0.03*	1						
11. Medium	0.05*	0.03*	0.01	0.03*	0.02	0.03*	-0.03*	0.01	0.02	-0.59*	1					
12. Large	0.07*	0.04*	0.01	-0.01	-0.03*	0.01	0.13*	-0.06*	-0.05*	-0.54*	-0.36*	1				
13. R&D intensity	0.01	0.05*	0.06*	0.21*	0.15*	0.21*	0.01	-0.20*	0.26*	0.40*	-0.09*	-0.37*	1			
14. Product innovation	0.15*	0.15*	0.18*	0.10*	0.18*	0.21*	-0.04*	0.02	0.01	0.00	0.04*	-0.04*	0.13*	1		
15. Local funding	0.12*	0.13*	0.15*	0.38*	0.17*	0.31*	0.03*	-0.11*	0.13*	-0.01	0.03*	-0.01	0.32*	0.13*	1	
16. EU funding	0.04*	0.04*	0.07*	0.19*	0.10*	0.18*	0.12*	-0.26*	0.25*	-0.04*	0.00	0.04*	0.23*	0.03*	0.21*	1

*$p < .05$

CHAPTER 3
Environmental innovation and its impact on employment

This paper examines the relationship between environmental innovation and employment from firm-level evidence. The data is taken from the Spanish Technological Innovation Panel (PITEC) survey and it covers the period of 2007-2011. The increasing relevance of environmental issues for the Spanish economy, its unemployment problem and the uniqueness of the Spanish innovation structure (De Marchi, 2012) make it a proper and interesting context to investigate environmental innovation dynamics. Based on our regression results on more than five thousand firms, we find an increase in employment for environmental innovators, as compared to non-environmental innovators and non-innovators, both before and during the Spanish crisis that started in 2008. The increase in employment is higher for dirty industries. Our results show that no matter firms introduce environmental innovation voluntarily or merely to comply with regulations, they create jobs. In addition, our results show a positive and significant relationship between employment and firms that report an increase or at least no change in the degree of importance paid to environmental innovation. This analysis has major policy implications on the Spanish economy, which is experiencing a severe unemployment problem.

3.1 Introduction

Undesirable environmental consequences from human activities advance at an alarming speed (Pacala & Socolow, 2004). From climate change and global warming leading to melting ice cap, to stronger storms and hurricanes and major flooding (Patz, Campbell-Lendrum, Holloway, & Foley, 2006; Easterling et al., 2000) or even to China's toxic air pollution that is so bad now it resembles a 'nuclear winter' (Kaiman, 2014). And the list continues on. Our technologies have indeed helped elevate our lives in an unprecedented manner, but we will soon outstrip these advantages if growth continues in this way.

As corporations have been portrayed as one of the key causes of current environmental state, numerous firms take on active roles in environmental management (Walker & Wan, 2012). Different actions are set out in favor of environmental protection and improvement. Some firms merely adopt the management of the environment, while some are being more strategic by encompassing environmental and economic aspects together through environmental innovation development. Not only because corporations are being scrutinized and put under pressures to respond, but also the increasing regulatory pressures and public incentives control and induce firms towards innovation developments with positive environmental implications (Bilbao-Osorio et al., 2012; Johnstone, Hascic, & Ostertag, 2008).

From the perspective of the economy at large, one of the topics commonly addressed during political debates concerns the question of how firms' transformations towards being green affect economic performance and employment (Rennings, Ziegler & Zwick, 2004). For instance, the Strategy EU2020 sets out guidelines for a new economy where the crisis should be turned into an opportunity for creating jobs, building a smarter and greener economy that rest on innovation and better use of resources (Europe 2020, 2014). Innovation literature and existing empirical evidence shows that the relationship between technological progress and job creation is clearly not negative (Harrison et al., 2008; Rennings et al., 2004). In contrast, environmental innovation leads to an increase, a decrease or even no effect on job creation. For instance, environmental product innovation has a positive effect on employment (Rennings et al., 2004); while cost reductions envisaged by environmental innovation create job losses and innovations purely motivated by environmental goals have no effect (Rennings & Zwick, 2002). With the few empirical works that exist, these studies

are weak because many works lie in case study methodology (Rennings et al., 2004). The consequences of green innovation on job creation are thus of our particular interest as the relationship is not particularly well-known and the views and impacts indeed spur ongoing debate.

In an effort to resolve this seeming paradox, the focus of our paper is to estimate the effect of environmental innovation on job creation from the best data available at hand, considering the scarcity nature of environmental innovation data (Horbach & Rennings, 2013). We base our study on the Spanish Technological Innovation Panel (PITEC) survey of more than five thousand firms during the period of 2007-2011. PITEC is based on the Community Innovation Survey (CIS) framework, which is a valid tool in studying innovation and is one of the most used datasets for studying innovation (Laursen & Salter, 2004, 2006). It is carried out yearly by the Spanish National Statistics Institute (INE) in collaboration with the Spanish Science and Technology Foundation (FECYT) and the Foundation for Technological Innovation (COTEC). The paper contributes in several important ways.

First, this paper tries to fill the gap, at least partially, by providing more empirical evidence about the impact of environmental innovation on job creation at firm-level. As PITEC is based on CIS framework, it enables direct comparisons of this work with previous empirical literature as well as future research using similar datasets. Not only that this paper helps to enlarge the very few findings that exist in this field, but it is also useful towards the design of micro-policies that will help to improve growth in employment, especially the employment crisis in Spain.

Second, we address criticisms from prior research concerning the needs to expand the study on firm's environmental friendliness to other settings outside the predominant U.S. sample (Walker & Wan, 2012). In this paper, we focus on Spanish firms. Spain is a moderate innovator (Hollanders & Es-Sadki, 2013) with gross domestic R&D expenditure in 2011 roughly 0.5% below the European Union (EU) average (Eurostat, 2013), yet Spain is very advanced in terms of environmental innovation. In 2011, Spain's composite index of eco-innovation scoreboard was 28% above the EU27 average (EIO, 2011; Sorli & Zambrano, 2011). Many environmental efforts both at national- and autonomous community-level have continued to offer a range of strategies and documents related to innovation and sustainable development such as an environmental technology platform (PLANETA) to promote green growth and co-operation on environmental technologies among public and private research

organizations (OECD, 2012). To date, voluntary green certifications have been adopted countrywide and have received a high recognition among Spanish firms. Spain is the first country in Europe and the third in the world with 16,433 ISO14001 certificates. The number of eco-management and audit scheme (EMAS) certified organizations is as well very high, with 1,235 certified workplaces (Sorli & Zambrano, 2011). Moreover, Spain aims to use environmental innovation to help boost economic growth (Barranco, 2013). The expenditures on environmental protection in 2011 stand at 2.39 million Euros, representing a 0.2% increase from the previous year (INE, 2013a). The increasing relevance of environmental issues for the Spanish economy, its unemployment problem and the uniqueness of the Spanish innovation structure (De Marchi, 2012) make it a proper and interesting context to investigate environmental innovation dynamics.

Lastly, we present the results in aggregate manner like in previous studies as well as distinguishing between types of environmental innovation that exists. We decompose environmental innovation into voluntary and compliance-driven.

From our results, we can establish a 'trace' of an increase in employment for environmental innovators, as compared to non-environmental innovators and non-innovators, both before and during the Spanish crisis. The increase in employment is higher for dirty industries. Our results show that no matter firms develop environmental innovation in order to comply to regulations or voluntarily, the bottom line is that they create jobs. In addition, our results show a positive and significant relationship between employment and firms that report an increase or at least no change in the degree of importance paid to environmental innovation.

The remainder of the paper is organized into four parts. Part two focuses on the literature explaining what environmental innovation is and its relation to job creation at firm-level. In Part three, we present the data and methods. In Part four, we analyze the results. Part five discusses and part six concludes.

3.2 Literature review and hypotheses

3.2.1 Environmental innovation and employment

In recent years, environmental technologies have received a lot of attention from scholars and policymakers alike. Despite its importance, the study about the impact of

environmental innovation on job creation at the macroeconomic-level is still rare (Pfeiffer & Rennings, 2001; Rennings et al., 2004) and very perplexed, notably when coupled with the effect from environmental policies.

On one hand, environmental regulations have created many new firms, in which according to the literature, firm entry is an important source of employment growth (Harrison et al., 2008). For example, a group of entrepreneurs saw an increase in environmental stringency as an opportunity and founded a new firm called LanzaTech in 2005. It develops and commercializes technologies that turn carbon monoxide into low-carbon fuels such as ethanol, and chemicals such as propylene for plastic. One of its most recent projects is with Baosteel, one of China's largest steel manufacturers. (LanzaTech, 2014; Tilley, 2014). On top of that, environmental regulations have resulted in entirely new industries such as those of 'green industry'. In many cases, green industry is characterized by substantial potential for growth. The latest report on environmental sector in Spain shows that employment in this sector has grown considerably despite economic and unemployment crisis. In 2011, employment in the sector represents 2.62% of the working population. The structural change in the society from Spanish's sustainable economy bill is also expected to create up to 2.8 million green jobs by 2020 (Jiménez Herrero & Leiva, 2011). In this regard, environmental innovation impact on employment is positive.

On the other hand, clean production reduces demand for material or energy and thus reduces demand for labor in these industries. The net effect of green innovation on employment is therefore uncertain (Pfeiffer & Rennings, 2001).

It is no doubt necessary to understand the impact of technological change at the macro-level (see Pfeiffer and Rennings (2001) for the discussion of green innovation on employment at the economy-level). However, it also makes sense to go down to the micro-level. After all, the change starts from individual firms. The remaining of the paper focuses only on firm-level effect.

Comparing with evidence of the impact of technological progress on labor demand at firm level, a basic distinction is drawn between product and process innovation. Both kinds of innovation can be associated with compensation effects (or employment stimulating effects) and displacement effects (or labor-saving effects) which reduce employment. (see Table 1, Harrison et al. (2008) and Dachs and Peters (2014) for further detail).

TABLE 1
Effects of product and process innovation on employment at firm level

	Displacement effect	Compensation effect
Product innovation	*Productivity effect*: (-): New products require less (or more) labor input *Indirect demand effect*: (-): Decrease in demand of existing substitutes	*Direct demand effect:* (+): New products increase overall demand *Indirect demand effect*: (+): Increase in demand of existing complementary products
Process innovation	*Productivity effect*: (-): Less labor input for a given output	*Price effect*: (+): Cost reduction passed on to price expands demand

Source: Dachs & Peters, 2014

Existing studies differ widely in terms of modeling strategies and methods. A study by Harrison et al. (2008) agrees with the already existing literature. Their results illustrate a strong positive effect of product innovation on employment. Bogliacino and Pianta (2010) distinguish between innovation's technological and cost competitiveness. They find that technological competitiveness has a significant positive effect on labor inputs, while cost competitiveness has a negative impact. Lachenmaier and Rottman (2011) find a positive effect on employment growth for both product and process innovation, with process innovation having higher effect than product innovation. Dachs and Peters (2014) show that foreign-owned firms experience higher job losses than domestically-owned firms due to general productivity increases and process innovation. At the same time, the impact of product innovation on employment is larger for foreign-owned firms. In general, results show innovative firms clearly have higher employment record (Dachs & Petersm 2014; Harrison et al., 2008; Lachenmaier & Rottman, 2011).

The very few prior environmental innovation studies are in line with conventional innovation literature. Positive effects of environmental-innovations on employment are detected. Horbach and Rennings (2013) show that though environmental product innovation does not trigger employment growth, green process innovation leads to job creation, particularly for green process innovations that lead to material and energy savings. Rennings et al. (2004) find that product environmental-innovations have a positive effect on the probability of an employment increase. Rennings and Zwick (2002) illustrate that environmental innovations have a small but positive effect on employment. The shift from end-of-pipe technologies to cleaner production creates jobs. Overall, there appears to be a positive relationship between employment and environmental innovation.

Although firms might be doing the similar type of environmental innovation because, say, they are located in the same region and are subject to the same set of environmental regulations, their impact on employment may differ because of the ex ante heterogeneity among them. Certain industries may be more likely than other industries to increase employment, given that they do environmental innovations. Specifically, we focus on one source of ex ante heterogeneity across firms, which is the industry firms belong to. This is whether or not the firms belong to a so-called 'dirty' or 'clean' industry. We base our typology on not only the pollution level but also toxins as according to the latest Toxic Release Inventory (TRI)'s annual report of 2011 and the US Environmental Protection Agency (EPA). See Appendix A for further detail. This typology is more appropriate to study environmental innovation than the usual manufacturing versus service industries in the traditional innovation.

Firms in dirty industries are more scrutinized by the public as well as are subject to stricter and more environmental regulations than firms in clean industries. As a result, they may have stronger internal environmental orientation. Environmental innovations for dirty firms may have a much substantial meaning than for clean firms. They may analyze new product development for the whole life cycle rather than symbolically such as the end-of-the-pipe technologies. For example, Dangelico and Pujani (2010) report that one of the managers in their study from the wood industry emphasizes going beyond 'cradle to grave' approach. He says that "the product development process in our company is strictly focused on eco-design and therefore on life cycle thinking… for the environmentally friendliness of our products, we use the necessary quantity of materials without exceeding in the use, we reduce the environmental impact of production process through the use of renewable energy and of water and energy efficient machineries… we use only FSC or PEFC certified wood… we try to create a network to obtain a short supply chain… products can be reused (with and without repairing),… collected, dissembled and components recycled… Our product is different from a 'cradle to grave' path because it follows a 'cradle to cradle logic'" (P. 478). Another manager from a chemical industry in Dangelico and Pujani (2010)'s study points out that "regulations represent for us constraints but also caution for avoiding risks of activity breakdown, money losses or damage to the company image" (P. 474). He further adds that "the reduction of packaging materials and of environmental risk is quantified and easily recognizable at the eyes of our main market, and so environmental innovations in products and packaging gives added value to our company" (P. 476).

Taken together, by being in a dirty industry, firms may feel stronger need to differentiate themselves more than clean firms in order to avoid being punished by the public from not being green or to capture the opportunities in the green markets. Furthermore, just the fact that these firms are in dirty industry, with the improved environmental technologies, the public might feel like these firms provide substantial change towards sustainability. This is as compared to clean industry where the public probably does not notice, care, or feel firms' environmental impact as much since the existing level of environmental footprint may be small. The public may respond to environmental innovation from dirty industry more positively. Subsequently, this new green product development may result in higher potential and higher substantial impact to market success and competitive advantage. We thus expect the effect of environmental innovation on employment to be stronger than for clean industries. We posit the hypothesis as follow:

> *H1: At firm-level, environmental innovators create more jobs than non-environmental innovators and non-innovators. This increase is greater for the so called 'dirty industries' than 'clean industries'.*

3.2.2 Voluntary versus compliance-driven environmental innovation

The green business literature usually makes a distinction between firms that adopt a more proactive or voluntary stance, taking into account a variety of forces other than government regulations, versus firms that are compliance-driven with a mere aim to meet legal requirements (Buysse & Verbeke, 2003; Schot & Fischer, 1993). We distinguish between the different types of environmental innovation, not only because there exist different types of environmental innovation (Frondel, Horbach & Rennings, 2007; Kemp & Pearson, 2007; Rennings et al., 2004), but also the expected outcomes on employment are different (Horbach & Rennings, 2013). Consequently, we combine Renning's (2000) technology-push and market-pull factors together and call it 'voluntary', or we can also think of it as 'proactive'. The rationale behind is that firm's decision whether or not to develop environmental innovation is voluntary. The decision is not forced upon by law. While for regulatory-push factor, we call it 'compliance-driven environmental innovation'. In this case, firms develop environmental innovation to conform to legal requirements.

Theoretically and empirically, proactive corporate environmental strategies that go beyond compliance with environmental regulations are found to be associated with improved financial performance (Klassen & McLaughlin, 1996; Klassen & Whybark, 1999; Russo & Fouts, 1997) and competitive advantage (Aragón-Correa & Sharma, 2003). The literature also shows that there is a market for green products (Dangelico & Pujari, 2010; OECD, 2013). Dangelico and Pujari (2010) state that "the size of green markets is increasing and is likely to get bigger in the future" (p. 473). Green innovation indeed seems to have potential in leading firms to achieve growth.

Prior empirical evidence agrees with the above arguments. When the goal behind developing environmental innovation is driven by market share or to respond to competitors' actions, there is a positive effect on the probability of an employment change (Rennings et al., 2004). Moreover, environmental innovation that leads to material and energy savings induce cost savings which lead to higher competitiveness of firm, and subsequently, higher employment (Horbach & Rennings, 2013). As such, no matter the goal of environmental innovation is to increase market share, to improve the image, or to save costs, once it is a voluntary and proactive, we expect a positive impact on employment.

In contrast, some researchers argue that increased environmental regulations could lead to higher costs, unproductive investments or even a possible loss of competitive advantage (Walley & Whitehead, 1994). Firms' response to regulations may become very expensive when faced with rapidly evolving and increasingly complex and severe environmental regulations (Berry & Rondinelli, 1998). Others, such as Porter and van der Linde (1995) argue that stringent environmental regulations provide firms with opportunities for improved efficiency. It appears the effect on employment due to environmental regulations can go in both directions.

Horbach and Rennings (2013) illustrate that when environmental-innovation is driven by regulations, there is no significant increase in employment. Stringency of environmental policies is known to lead to more end-of-the-pipe type technologies (Aragón-Correa & Sharma, 2003; Frondel et al., 2007; Hart, 1995). Rennings et al. (2004) show that the effect of end-of-the-pipe technologies on employment is negative. At the same time, Rennings et al. (2004) also show that environmental regulations in order to induce environmental innovation have both positive and negative influence on employment. As such, we expect compliance-driven to result in a lower level of

employment increase as compared to voluntary-driven environmental innovation. We postulate the hypothesis as follows.

> *H2: Environmental innovators that develop environmental innovation voluntarily create more jobs than environmental innovators that develop environmental innovation due to compliance with environmental regulations.*

3.3 Methodology

Data

The sample of firms for this study is drawn from the Spanish Technological Innovation Panel (PITEC) survey[2]. It is carried out yearly by the Spanish National Statistics Institute (INE) in collaboration with the Spanish Science and Technology Foundation (FECYT) and the Foundation for Technological Innovation (COTEC). Most questions in the questionnaire are related to firms' innovation behavior in the preceding two years.

The use of PITEC survey provides several advantages. First, PITEC is a large-scale survey that offers the opportunity to study environmental innovation. Second, PITEC is based on the Community Innovation Survey (CIS) framework, one of the most used datasets for analyzing innovation (Laursen & Salter, 2004, 2006). Thus, PITEC is a valid tool in studying innovation and offers direct comparisons of this work with other works based on CIS.

At present, PITEC sample contains over 13,000 firms. The degree of representativeness of the population depends on firm size. The dataset is representative of the population for firms with more than 200 employees. However, the representativeness of firms with less than 200 employees is biased towards firms having external and/or internal R&D.

We combine PITEC survey of year 2011 together with PITEC surveys of 2007-2010, with 2011 as the latest available dataset. This helps to reduce the potential problem of common method variance (Podsakoff & Organ, 1986) and reverse causality (Wooldridge, 2013). Nonetheless, we perform Harman's one-factor test to check for

[2] The dataset, the questionnaire and the description of each variable is available free of charge at the website http://icono.fecyt.es/PITEC/Paginas/por_que.aspx

potential common method variance. The results from unrotated principal component analysis with and without varimax rotation performed on all variables suggest no potential problem of common method variance. No single factor emerges and no factor accounts for a majority of variance (with 21.60% for the first factor).

We screen PITEC dataset three times in selecting firms. First, only those firms that exist from the period of 2007-2011 are selected due to the changing nature of the sample. Second, we drop petroleum industry as there are only two observations. Last, we drop observations for which we cannot compute employment, environmental innovation and other essential information due to incomplete data. After applying these screens to the population, we end up with 5,137 firms for our study sample, without missing values.

Econometric model

According to the literature, a model based on a static estimation equation that uses cross-sectional data leads to problems. The high costs of hiring and firing, especially in European economies, are well-known arguments as to why there is a time lag between implementation of innovation and its effect on employment adjustments (Lachenmaier & Rottman, 2011). Other relevant studies also allow for an adjustment process by including lagged values of innovation (van Reenen, 1997). These authors test the relationship based on a panel data.

However, the changes in the questions in PITEC questionnaire pose challenges for inter-temporal analysis. Additionally, data on environmental innovation and other essential variables are available in a block of 2-year period. We thus base the construction of our econometric regression by adapting from Harrison et al. (2008)'s model and combine it with Lachenmaier and Rottman (2011). We assume the two-stage decision process in employment as in Konig et al., (1995) and Rennings et al., (2004), where firms first decide to invest in environmental innovation, and then decide to increase or decrease volume of labor input at a second stage. Our study focuses only on firms' second-stage employment decision. We do not consider why and how firms innovate and grow. We perform OLS with robust standard errors to account for heterogeneity and lack of normality. We regress log of employment level of firm *i* at time *t* on environmental innovation at time *t-1* that is referred to environmental innovation objectives in the last two years.

We perform additional robustness checks. We run our model with robust regression to address potential outlier problem. We run generalized linear model (GLM) to address the issue of heteroskedasticity. A different specification for our explanatory variable is also used. Instead of a dummy, we perform a factor analysis on the four environmental innovation objectives. We try adding controls to our model. For instance, we try controlling for the supply situation in the industry that can have potential influence on firms' decision to employ more or less employees, using the average labor cost per industry as provided INE's annual labor cost surveys. Furthermore, we run regressions with different specifications for our proxies for some control variables. The results are consistent.

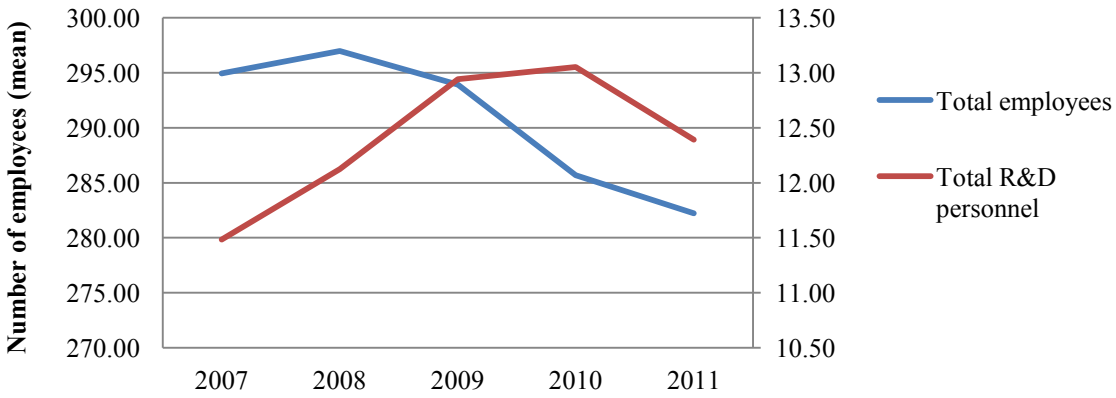
Dependent variable

The dependent variable, employment, is obtained from PITEC survey. The dataset provides very detailed information on employment such as total employment, total employment for internal R&D by occupation and by education level and whether or not they are full-time. Unfortunately, PITEC data is anonymized to avoid disclosure problems. We could not complement this dataset with external information.

Prior researchers (e.g., Harrison et al., 2008) use rate of employment growth as a proxy to test if innovation stimulates employment. In our study, however, we follow the approach of Lachenmaier and Rottman (2011) in using natural log of employees. Employment tends to be quite stable over time, as compared to for instance growth in sales. The use of our proxy is thus appropriate.

Figure 2 illustrates the trend of firm's total employment and total R&D personnel from 2007 to 2011. We can see that the trend in employment in Spain is decreasing. This is not surprising considering the Spanish crisis, particularly in employment. The number of R&D personnel also decreases but at a slower rate. Again, the result is to be expected, given Spain's overall decrease in expenditure on innovation, with the annual growth rate of -8.8% from 2010 to 2011 (INE, 2013b).

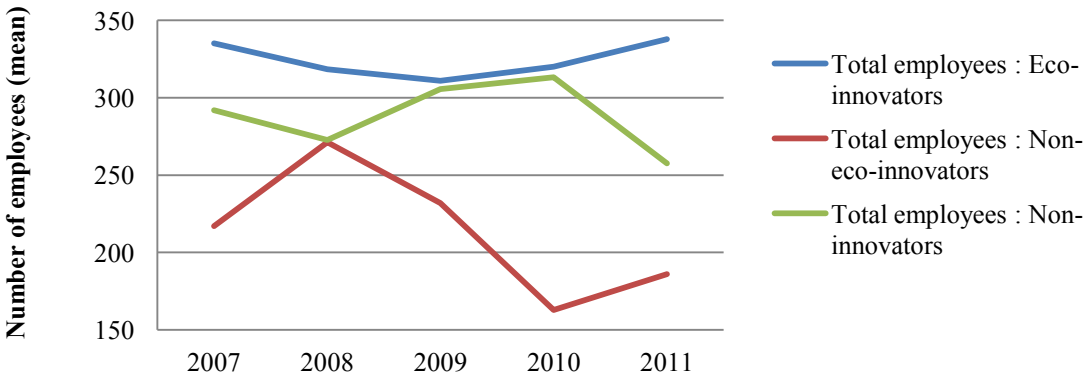
FIGURE 2
Total employees and total R&D personnel



We further break down the data into three types of firms to examine any differences. In this dataset, about 65.51% of firms are innovators. They are identified by their answer to the question regarding whether or not they have introduced innovation in the previous two years. Among these innovators, 73.40% are environmental-innovators. They are identified by their answers on the degree of importance paid to environmentally-related innovation objectives. It might seem that the number of green innovators in Spain is high in our sample. However, when we consider the fact that Spanish firms regard environmental issues highly, it is not surprising. Spain is the first country in Europe and the third in the world with 16,433 ISO14001 certificates. The number of eco-management and audit scheme (EMAS) certified organizations is as well very high, with 1,235 certified workplaces (Sorli & Zambrano, 2011).

In Figure 3, we show total employment for environmental-innovators, non-environmental innovators and non-innovators. Environmental-innovators were less affected by the Spanish crisis, with smaller rate of decrease from 2007 leading to 2009. They performed better than the other two types of firms in terms of employment, with an increasing trend from 2009 to 2011. Non-environmental-innovators were affected severely by the crisis, with the sharp decrease in employment. However, non-environmental-innovators performed better in terms of employment as compared to non-innovators, with an increasing trend from 2010 to 2011.

FIGURE 3
Total employees and total R&D personnel by types of firms



Explanatory variable

Our independent variable, environmental innovation, is based on a self-report data on the objectives of innovation firm introduced in the last two years. In many previous studies, environmental innovation has been commonly measured using questionnaire surveys (Anton et al., 2004; Christmann, 2000). Kemp and Pearson (2007) also suggest using a self-reported input-oriented data rather than using the extensively employed measures of environmental investments (inputs) or environmental patents (outputs) (Nameroff, Garant, & Albert, 2004). Both environmental R&D expenditures and environmental patents pose problems (Toshi et al., 2007). Drawing exact boundaries between different investment objectives is by no means straightforward (Grupp, 1998). Environmental R&D expenditures can be used to show how much is spent on equipment and processes that will result in environmentally-products and processes, but we do not know if they are spent on new to the market innovations or old standardized ones (Lázaro, Dorronsoro, Casas, Rodríguez & Sedano, 2008). R&D, in general, captures only parts of innovation. It is usually more important for high-tech products but less so for other types of innovation or in small firms (Kemp & Pearson, 2007). Particularly, roughly 70% of our sample is SMEs firms. Furthermore, the patent classification system has not yet provided specific categories for environmental patents. There is still no widely accepted agreement in the literature as to what constitutes environmental technology. Green patent identification is based solely on researchers' judgments and understandings (Kemp & Pearson, 2007) and eco-patents mainly measure identifiable inventions that are mostly end-of-the-pipe technologies or

green product innovations (Arundel & Kemp, 2009; Kemp & Pearson, 2007). Many innovations that take the form of changes in production processes such as 'clean production' are harder to identify and patent. Therefore, not all environmental innovations are patented. In addition, patenting activity in Spain, including eco-patenting is low. Spain has one of the lowest ratios of patents per million habitants in Europe according to the European patent office (Sorli & Zambrano, 2011). As such, these proxies could lead to over- or under-estimation of innovation (De Marchi, 2012); we can argue that the use of objective, as in our study, is not inferior to other proxies of environmental innovation.

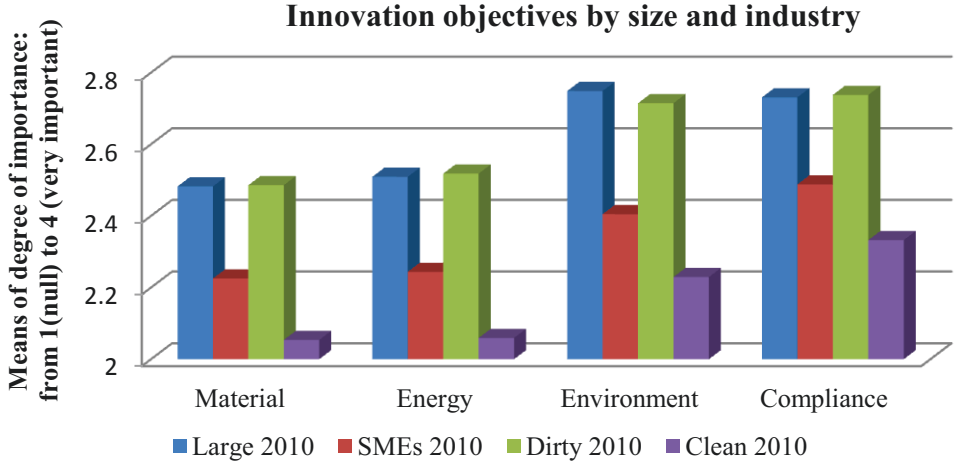
PITEC provides information on the degree of importance of the following firm's innovation objectives: 1) using less material; (2) using less energy; (3) lower impact on the environment; and (4) complying with the requirements on environment. The degree of importance for each objective is based on a Likert scale of 1 (very important) to 4 (null). We reverse the scale into 1 (null) and 4 (very important) for ease of understanding. We follow the approach of Kunapatarawong and Martinez-Ros (2014) when constructing environmental innovation. We first assign binary values for each objective. A response of 4 (very important) or 3 (important) receive a binary value of 1, where responses of 2 (some importance) and 1 (null) receive a binary value of 0. We then aggregate these answers and rescale the total score into 0 and 1, with firms having 0s across all four objectives as 0, and 1 otherwise.

From the data, firms are increasingly paying more attention to environmental innovation, with year 2010 showing higher average of importance paid to all environmental innovation objectives than 2008. On average, firms pay more importance on decreasing environmental impact and to comply with environmental and health regulations than on reducing material and energy usage per unit of production input.

Figure 4 illustrates the means of the degree of importance paid to each environmental objective when firms innovate by size and industry. On average, dirty industries and larger firms are more concerned with environmental innovation than clean industries or smaller firms. In PITEC, the industry is classified according to the Spanish National Activities Classification, CNAE2009. We distinguish dirty from clean industries based on not only the pollution level but also toxins as according to the latest Toxic Release Inventory (TRI)'s annual report of 2011 and the US Environmental Protection Agency (EPA). See Appendix A for further detail. We perform both t-test and Wilcoxo-Mann-Whitney test (not reported here) to test for the mean differences

among these groups: manufacturing versus service industry, SMEs versus large firms, and dirty versus clean industries. Both tests are used as the use of t-test of difference on Likert scale can be highly criticized due to the nature of Likert scale that is not continuous. The results from both tests confirm that there are differences among these groups.

FIGURE 4
Innovation objectives by size and industry



Unfortunately, though PITEC incorporates the questions asking about percentage of environmental R&D, the data is not available. Moreover, as PITEC is not specifically designed to investigate environmental innovation per se. Our proxy could thus be criticized. To mitigate potential problems and to provide robustness of our analyses, we employ different specifications for our environmental innovation measure.

Control variables

Dummy variables, valuing 1 if the firm is a listed firm, private firm or institution, are included to control for firm characteristic. We also control for public financing in the form of subsidies. Almost 50% of Spanish firms receive some form of public support for R&D activities (INE, 2010, 2011). We can thus expect that public financing may influence employment growth. We also control for wages as a proxy for the demand situation in the industry (Lachemaier & Rottmann, 2011). As the information on firm wages is not available, our next best approximation available is the average industry wage within a 2-digit National Classification of Economic Activities 2009 (CNAE2009). We obtain the information from INE's annual wage structure

survey that reports the average annual earnings per worker per industry. As well, we control for market characteristic by including sales growth per industry. The information on prices is unavailable at firm level. To deal as best we can, we deflate growth in nominal sales with consumer price index as reported by INE. Different industries are subject to different market and economic contexts (Lachenmaier & Rottman, 2011). We can expect that this results in the differences in workers' structure and demand among industries. We include forty-two industry dummies as according to CNAE2009.

3.4 Results

Table 2 reports correlation coefficients. The untransformed value for employment averages 282 employees, with the maximum value of 38,619 employees. Examination of the correlations indicates that organization's environmental innovation is positively related with firm's employment. Specifically, green innovation is correlated significantly with firms having received subsidies from autonomous community and at the national level ($r = 0.08$, $p < .05$; $r = 0.10$, $p < .05$). As well, firms having received national-level subsidies ($r = 0.12$, $p < .05$) or subsidies from the European Union ($r = 0.04$, $p < .05$) correlate positively with employment. Average wage by industry also correlates positively with employment ($r = 0.13$, $p < .05$). The correlations indicate low probability of multicollinearity problem. Nonetheless, we further verify using Collin command in Stata. The variance inflation factors (VIFs) are in the range of 1-2.29 with the mean of 1.37, indicating no evidence of multicollinearity.

TABLE 2
Correlation Coefficients

	1	2	3	4	5	6	7	8	9	10
1. Employment	1									
2. Green innovation	0.11*	1								
3. Listed firms	0.15*	-0.04*	1							
4. Private firms	-0.08*	0.01	-0.72*	1						
5. Institutes	-0.04*	0.03*	-0.02	-0.67*	1					
6. Autonomous community subsidies	-0.01	0.08*	0.03*	-0.14*	0.17*	1				
7. National subsidies	0.12*	0.10*	0.01	-0.10*	0.13*	0.27*	1			
8. EU subsidies	0.04*	0.02	0.10*	-0.25*	0.25*	0.24*	0.26*	1		
9. Industry wage	0.13*	0.01	0.10*	-0.02	-0.08*	-0.03*	-0.03*	-0.04*	1	
10. Industry sales growth (deflated)	-0.01	0.02	-0.01	0.01	0.01	-0.01	0.02	0.03	-0.01	1
Mean	4.10	0.71	0.03	0.95	0.02	0.28	0.30	0.07	24751.59	0.03
s.d.	1.55	0.45	0.15	0.21	0.14	0.45	0.46	0.26	3971.96	0.66
Minimum	0	0	0	0	0	0	0	0	14629.55	-1.02
Maximum	10.56	1	1	1	1	1	1	1	48803.35	29.18

*$p < .05$

Table 3 reports results for hypotheses 1-2. Column (I) reports the results of the full model on the effect of environmental innovation in 2010 on employment in 2011. Column (II) reports the results with the interaction effect. The results support hypothesis 1. We find the increase of employment for environmental innovators and the effect is stronger for firms in dirty industries. The signs of most of the control variables are as expected. Listed firms are positively related with employment while private firms are negatively related. The relationship between employment and firms that have received subsidies from the Spanish government (national level) and the EU in the previous two years are positive. For manufacturing industry, firms in food, beverage and tobacco, paper and graphic arts, rubber and plastic products, metallurgy, motor vehicles experience an increase in employment. For service industry, the industries that create jobs are construction, wholesale and retail, transportation and warehousing.

In Column (III) of Table 3, we distinguish between voluntary and compliance-driven environmental innovation, testing hypothesis 2. We aggregate the answers for (1) reducing material; (2) reducing energy; and (3) lower environmental impact together and rescale the total score into 0s and 1s. We then use this score as a proxy for environmental innovation of voluntary type as these actions are completely voluntary. For compliance-driven environmental innovation, we use the same method to rescale a Likert scale of 1-4 (null to very important) into binary values. Firms reporting that they innovate in order to comply with environmental requirements receive a value of 1, and 0 otherwise. For Column (III), we perform the test on the equality of the two coefficients. The results show that the two coefficients are the same. Hypothesis 2 is not supported.

TABLE 3
Regression results for environmental innovation

	(I) Full model: 2011	(II) Full model: 2011	(III) Voluntary vs compliance driven	(IV) Full model: 2009	(V) Positive change in green innovation
Green innovation	0.2400**	0.1950**		0 .1388**	
Dirty industry		0.1768**			
Green innovation*dirty		0.2093**			
Voluntary			0.2056**		
Compliance			0.1129*		
Change in green innovation					0.1696**
Constant	1.2032	2.2795**	1.1494	1.5768	1.0681
Controls:					
Listed	0.8543**	1.7656**	0.8649**	0 .0451	0.8325**
Private	-0.3461*	0.3191*	-0.3339*	-0.6402**	-0.3589*
Autonomous community subsidies	-0.0298**	-0.1385**	-0.0363	-0.2024**	-0.0149
National subsidies	0.5565**	0.4279**	0.5521**	0.4687**	0.5741**
EU subsidies	0.3138**	0.1611	0.3087**	0.5741**	0.3071**
Industry wage	0.0001*	0.0001**	0.0001*	0.0001*	0.0001*
Industry sales growth (deflated)	0.0124	-0.0238	0.0131	-0.0187*	0 .0172
Industry	Yes		Yes	Yes	Yes
N	5,137	5,137	5,137	5,137	5,137
R^2	21.59%	7.62%	21.84%	21.43%	21.38%
F	25.87**	35.32**	25.73**	25.18**	25.67**

*$p < .05$, **$p < .01$

We report additional results in Column (IV) and (V) of Table 3. Column (IV) investigates the impact of environmental innovation in 2008 on employment in 2009. Employment is consistently higher for environmental innovators than for non-environmental innovators in the period leading to the Spanish crisis. In Column (V), firms that report an increase or a constant degree of importance paid to environmental innovation from one period to another receive a value of 1, and 0 if firms report a decrease in the degree of importance. Instead of regressing employment in 2011 on environmental innovation in 2010, we regress employment in 2011 on the change in environmental innovation from 2006-2008 to 2008-2010. We are aware that firms' priorities might have changed over the years. It is one of the limitations of our model that we cannot address. The results show a positive and significant relationship between employment and firms that report an increase or at least no change in the degree of importance paid to environmental innovation.

3.5 Discussions

Our results show that environmental innovators increase employment more than non-environmental innovators and non-innovators, and the effect is stronger for dirty industries. Our results are consistent with previous studies (Horbach & Rennings, 2013; Rennings et al., 2004; Rennings & Zwick, 2002). It appears that market do reward firm's environmentally innovative behavior because environmental innovators seem to be better off than non-innovators or non-environmental-innovators if we judge it from the fact that these firms still expand and employ more people both before and during the crisis. Subsequently, such rewarding behavior goes back to the society in the form of increased employment.

Merely because of the fact that the firm is in a dirty industry, the idea for new environmental innovation may come more from firm's internal sensitive to environmental issues rather than from having to comply with regulations or customers' requirements in terms of environmental issues. This would make their strategies more proactive rather than reactive. Prior literature shows that proactive environmental strategies are associated with improved firm's financial performance (Klassen & McLaughlin, 1996; Klassen & Whybark, 1999; Russo & Fouts, 1997) and competitive advantage (Aragón-Correa & Sharma, 2003). Likewise, for whichever reasons, top management may be more personally committed to sustainability, thus helping to drive environmental innovation that may have substantial environmental impact and stronger economic impact. Similarly, these firms may have a clearer and a better specified plan to deal with environmental innovation than say cleaner industries that are less subject to scrutiny and environmental regulations. These plans are likely to be put in place as a result of a thorough study of the product-life cycle analysis, resulting in many advantages such as optimization in energy costs and packaging, logistical advantages, reduction in material consumption, lower risks for health and safety of consumers as well as employees, etc. After all, green markets do exist and is likely to get much bigger in the future (Dangelico & Pujari, 2010; OECD, 2013). In sum, these are likely to result in an increase in firm performance and consequently labor input.

From a macroeconomic background in Spain, the time period from 2007-2011 was characterized by an economic crisis and high unemployment rate that was at 21.6% in 2011, the highest in EU-27 (INE, 2012). Our results hence have serious policy implications. More efforts to promote and provide incentives towards green growth at

national- and autonomous community-level should be made in order to improve the overall Spanish framework regarding environmental technological competencies and consequences. After all, Spain aims to use environmental innovation to help boost economic growth (Barranco, 2013). Our results provide valuable evidence that Spain is heading in the right direction in terms of using green growth to boost growth.

Further, our study reveals that no matter firms develop environmental innovation merely in response to environmental regulations or they voluntarily develop environmental innovation, these environmental innovators create jobs. Though both cost-savings from managing resources efficiently and cost-increase from having to comply with regulations might lead to a decrease in employment, it seems environmental regulations can still become an opportunity for new business creation (Dangelico & Pujari, 2010), thus, job creation. Our results are consistent with Porter Hypothesis that environmental regulations provide firms with opportunities for improved efficiency; therefore, an increase in employment. It seems 'the end justifies the means'.

Care should be taken when interpreting this result. A myriad of environmental instruments on environmental innovation exist. With our proxy for compliance-driven environmental innovation, we cannot make distinction between command and control type or market-based regulations. End-of-the pipe technologies fall under the first category. Tradable emissions, environmental certificates or environmental taxes fall under the latter category (van Leeuwen & Mohnen, 2013). We cannot conclude that command and control type regulation is more effective than market-based regulation or vice versa. In addition, prior literature asserts that what determines the impact on the change in employment depends on the level of stringency and concreteness of environmental measures (Rennings et al., 2004). We cannot tell at which level of policy stringency triggers positive impact on employment through environmental technology developments.

Empirical work on environmental innovation-employment relationship can be influenced by a wealth of different factors. This work presents us with limitations.

First, PITEC dataset is not built specifically to assess environmental innovation. It limits our approach to measuring environmental innovation from innovation objectives with environmental concerns. We cannot tell the actual outputs or economic values from innovation objectives. We also cannot determine when or whether the objectives get turned into actual environmental-friendly technologies. Too, responses to

questionnaires can by seriously biased as respondents tend to present a socially responsible image of themselves or their firms (Berrone et al., 2013).

Second, our measure of environmental innovation is an all-encompassing construct. We could only distinguish voluntary from compliance-driven environmental innovation. We could not decompose our measure into more types of environmental innovation that exist.

Third, we only provide firm-level analysis on employment and environmental innovation. To draw implications for aggregate level from this study, caveats should be taken into consideration.

Fourth, we consider only the total level of employment. We do not consider its composition in terms of skills or types of worker. The demand for skilled labor might be higher than for unskilled labor, or even a decrease in a demand for unskilled labor in some cases. Our study could not address the possibility that environmental innovators lead to more or less employment of skilled or unskilled workers.

Future research could use other measures to help improve the analysis on the topic. Costs and benefits of environmental innovation vary and are probably correlated with employment changes incurred by them. The use of other measures of environmental innovation that incorporate costs and benefits factor into the measure would help to improve the analysis. An alternative measure can be sales or revenue growth due to environmental innovations. Another option can be environmental patent or the number of new environmental products or processes (Kemp & Pearson, 2007). In this manner, we would be able to estimate gross effect of environmental output on employment.

In addition, as we cannot supplement our analysis with external data due to confidentiality nature of PITEC dataset, we think it is important for future research to include information on environmental-related performance. For instance, the analysis could be improved by including a control for firms' environmental performance such as whether or not a firm is ISO14001 certified, EMAS registered, or the like. Firm's previous environmental performance or previous environmental crises might be a factor causing firms to be more or less attractive among employees. Prior literature shows that firms' corporate social performance (which includes environmental performance) is positively related to their reputations and attractiveness as employers (Turban & Greening, 1997).

The effect of environmental innovation on employment at the aggregate level is of great value for future research. As we do not consider why and how firms innovate and grow, future research on firm-level employment growth should be complemented with other firms' economic or regulatory situations or other organizational factors. For instance, the size of environmental innovation, the information on government policies influencing employment, bursts in capacity utilization and labor, or temporary organizational problems would help to improve the model (Harrison et al., 2008). Moreover, autonomous regions in Spain present considerable differences in their physical, social and economic conditions as well as in terms of environmental policies and public financing received (INE, 2012; OECD, 2004). A regional-level control should be taken into consideration. For future research at the aggregate level, as we do not observe the effect of firm entering or exiting in our sample, a full analysis incorporating entry, exit and competition between rival firms would be fruitful. Firm entry and exit are an important source impacting growth or decline in employment (Harrison et al., 2008).

Lastly, a great contribution that future research should attempt is to not only distinguish between green product and process innovation, but also to further subdivide. It would also be interesting to conduct comparable studies, especially comparing countries that are considered to be in an environmental innovation-rich context versus countries that are less developed in terms of being green. A comparable study on entirely different institutional, economical and environmental contexts would help to explain whether or not the structural effects play a large role in influencing firms to go 'green' or even more importantly to be sustainable. Such comparable study has both direct policy implications as well as indirect benefits on green consumerism and sustainable literature.

3.6 Conclusion

We can establish 'the existence' of a positive relation between variables proxying environmental innovation and employment at firm-level. For a variety of reasons, relatively little work has been completed, both theoretically and empirically, on the changes in employment as a result of environmental innovation. Results at the firm-level are still ambiguous and views about the impacts are highly controversial (Rennings et al., 2004). The novelty of our study is that, to our knowledge, this is one of

the very few statistical studies assessing the impact of environmental innovation on employment at the firm-level.

We base our study on PITEC dataset. The increasing relevance of environmental issues for the Spanish economy, its unemployment problem and the uniqueness of the Spanish innovation structure (De Marchi, 2012) make it a proper and interesting context to investigate environmental innovation dynamics. Our estimation results on more than five thousand firms show the increase of employment for environmental innovators, as compared to non-environmental innovators and non-innovators, both before and during the Spanish crisis that started in 2009. The increase in employment is higher for dirty industries. Our results show that no matter firms introduce environmental innovation voluntarily or merely to comply with regulations, they create jobs. In addition, our results show a positive and significant relationship between employment and firms that report an increase or at least no change in the degree of importance paid to environmental innovation. This study hopes to provide not only a clearer understanding of the impact of environmental innovation on employment at firm-level, but also policy implications on the Spanish economy where it has and is still experiencing a severe unemployment problem.

3.7 References

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3.8 Appendix A: Industry classification: Dirty and clean industries

Dirty	Clean
Agriculture, livestock, fishing	Garment
Extractive industries	Other machinery
Food, beverage and tobacco	Other transport equipment
Textile	Miscellaneous manufacturing
Leather	Machinery repair
Wood	Commerce
Pulp and paper	Warehousing
Printing	Accommodation
Chemicals	Telecommunication
Plastics	Information technology
Pharmacy	Software development
Non-metallic mineral products	Finance and insurance
Metallurgy	Real estates
Metal	R&D
Computers and electronics	Other activities
Electronics	Administrative services
Cars	Education
Shipbuilding	Social services
Airplanes	Arts, recreations and entertainment
Furniture	Other services
Energy and water	
Waste management	
Construction	